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TCELR: Trusted Cluster Based Energy And Lifetime Aware Routing Protocol For Wireless Sensor Network Using Hybrid Bird Swarm-Differential Search Algorithm

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Abstract

Wireless Sensor Networks are essential and most significant technology for send, receive and control or monitoring the data. In WSNs, the routing protocols are important one. The process of choosing the proper path for data travel from source to destination is routing protocol. Depending upon the network, channel parameters there are various difficulties available in while choosing path. Some routing challenges are data traffic, high energy consumption, storage capacity, bandwidth, classical IP-protocols not acceptance some sensor modes, node deployment etc. To overcome these problems during routing protocol process, we propose a trusted cluster based energy and lifetime aware routing (TCELR) protocol for WSN using hybrid bird swarm-differential search algorithm. In TCELR protocol, first, we introduce a chaotic bird swarm optimization (CBSO) algorithm for cluster formation. Second, we illustrate the improved differential search (IDS) algorithm to compute the trust degree of each client in the cluster. The highest trust node is considered as cluster head (CH) in the cluster and it is act as sink node of cluster members to perform intra cluster routing and Third, a scatter search based decision making (SSDM) algorithm is used for inter cluster routing to forward sensed data between different clusters. The performance of the proposed TCELR protocol is analyzed and the results are compared with the existing state-of-art routing protocols in terms of throughput, packet loss rate, end to end delay, network lifetime, packet delivery ratio and jitter.

Keywords: *TCELR, Chaotic Bird Swarm Optimization, Improved Differential Search, SSDM, Routing protocols***.**

1. Introduction

WSNs are generally examined as most significant advances for twenty-first century [1][2]. In the previous decades, it has gotten gigantic consideration from both scholarly community and industry everywhere throughout the world. A WSN (Wireless sensor network) commonly comprises of countless ease, low-control, and multifunctional remote sensor hubs, with detecting, remote interchanges and calculation abilities [3]. These sensor hubs convey over short separation by means of a remote medium and work together to achieve a typical assignment, for instance, condition checking, military exploration and new procedure control. The essential way of thinking behind WSNs is that, while the capacity of every individual sensor hub is constrained, the total intensity of the whole system is adequate to necessary strategic. There are a few applications are accessible utilizing of WSNs through sensor nodes. Once sent, the sensor centers must have the alternative to self-rulingly deal with themselves into a remote correspondence orchestrate. Sensor center points are battery-controlled and required to work without investment for a modestly noteworthy stretch of time. The essential part of the system is the sensor, basic for observing true physical conditions, for example, sound, temperature, dampness, force, vibration, weight, movement, poisons and so forth at various areas [5][6]. The modest sensor hubs, which comprise of detecting, on board processor for information handling, and conveying parts, influence the possibility of sensor systems dependent on community oriented exertion of countless hubs [7]. Vitality asset, figuring force and data transfer capacity of hubs in a remote sensor system are restricted so the steering convention plan of a remote sensor system is altogether different from the customary portable system [8]. Significant goals of the steering structure of a remote sensor system are to decrease vitality misfortune and improve the existence cycle of the system.

Methods of routing are required for moving information among the sensor hubs and base station [9]. Steering in WSN is unpredictable on the grounds that the quantity of one of a kind qualities with the way things are ridiculous to manufacture a worldwide tending to conspire for an enormous number of sensor hubs; also rather than ordinary correspondence frameworks all usage of sensor frameworks requires the surge of recognized data from various sources to a particular BS [10]. Distinctive steering procedures have been proposed for WSNs and these shows can be delegated per various parameters. A strong trust-mindful directing system (TARF) [11] is utilized to verify steering arrangements dependent on the exceptional qualities of asset compelled, the plan of TARF focuses on position and proficiency of energy. A system coding-based probabilistic directing (NCPR) plot gives vitality effective, dependable and reduces the communicate storm issue in a grouped WSN [12]. A safe hub disjoint multipath directing convention handles the information parcels are transmitted in a safe way by utilizing the computerized mark crypto framework [13]. Vitality and action mindful steering (EAR) [14] convention is found out and worked from the occasion movement designs. EAR is a web based steering convention picks the following jump hand-off hub by using: action design data in the ATPG diagram and file of vitality balance. Information steering for in-organize conglomeration (DRINA) system [15] used to lessen the quantity of messages for setting up a directing tree, expanded number of covering courses, high accumulation rate, and dependable information total and transmission. The mix of vitality collecting hereditary based inconsistent grouping and ideal versatile execution steering calculation (EHGUC-OAPR) [16] used to adjust the vitality utilization of the whole system and productively improve the information conveyance proportion. ALBA-R is a cross-layer plot [17] for merge throwing and it consolidates geographic directing, treatment of impasses, MAC, alert snoozing booking, and consecutive information parcel transmission for accomplishing a vitality effective information gathering instrument. A vitality adjusted directing technique dependent on forward-mindful factor (FAF-EBRM) [18] is utilized to choose next-bounce hub dependent on the consciousness of connection weight and forward vitality thickness. Solid responsive steering improvement (R3E) [19] is utilized to build the strength to connect elements. It improves the solid and vitality effective parcel conveyance against the questionable remote connections by using the neighborhood way assorted variety. Effective QoS-mindful GOR (EQGOR) convention chooses and organizes the sending competitor set in a proficient way, which is appropriate for WSNs in regard of vitality productivity, dormancy, and time unpredictability [20].

The rest of paper is pursues: In Section 1, we present in overview of routing protocols techniques and we analyzes the related works in order to proposed method in section 2. And Section 3, discussed on issues from previous methods and system model and we described briefly about proposed algorithm in Section 4. Section 5 analysis the result and discussion. Concludes this paper in section 6.

2. Related works

A numerous researches have been presented in the paper for the routing protocols for WSNs. A brief review of some recent researches is presented here.

Zahedi et al. [21] have proposed swarm intelligence based routing protocol (named SIF), so as to conquer the referenced downsides. A fuzzy c-implies bunching calculation is used to group all sensor hubs into adjusted bunches, and after that suitable group heads are chosen by means of Mamdani fuzzy derivation framework. This technique not just certifications to create adjusted groups over the system, yet in addition can decide the exact number of bunches. In fuzzy depended routing protocols in research, the fuzzy guideline base table is characterized physically, which isn't ideal for all applications. A cross breed swarm insight calculation depends on firefly calculation and mimicked toughening to upgrade the fuzzy standard base table of SIF. The wellness capacity can be characterized by the application details.

Zhang et al. [22] have proposed a vitality adjusted algorithm of clustering and an IRPL convention directing system An IRPL steering convention was proposed in this examination to satisfied the vitality balance prerequisites of remote sensor systems. This directing convention presents another steering topology control model in which the correspondence region is separated into rings of equivalent zone. Best transfer hubs, ideal sending correspondence region, and ideal bearing edge are additionally characterized. The bunching calculation may utilize to find the optimal number of group heads by suspicion of the system model. Joined with the bunching likelihood model and the hub rivalry system, the group head hub in the remote sensor system was utilized to finish the grouping procedure.

Mohemed et al. [23] have proposed on-gap youngsters reconnection (OHCR) with neighborhood nature and on-gap alert (OHA) with worldwide nature. The conventions safeguard the availability of all single arrangement stage; single way coordinates with any topology in a vitality effective way by maintaining a essential distance from topology transformation overhead. The recreation results indicated proposed conventions beat the ongoing ones as far as system lifetime, hub misfortune rate, and system overhead. With the end goal that, the two conventions are analyzed on both degree compelled tree (DCT) and briefest way tree (SPT) to give about half to 75% expansion in system lifetime over the ongoing routing protocols.

Mohamed et al. [24] have proposed Degree Constrained Tree (DCT) steering convention as far as vitality utilization during parcel transmission. The hub degree that boosts organize lifetime systematically applied to haphazardly dispersed DCT of homogeneous sensor hubs. The ideal hub degree that prompts lifetime expansion and breakdown vitality minimization was demonstrated to be 3. The quantity of levels in the tree was determined regarding hub degree. CDA steering convention that depends on DCT with ideal hub degree is intended to give high system execution regarding system lifetime while multiplying the soundness time frame and limiting the normal pace of vitality exhaustion contrasted with its companions.

Darabkh et al. [25] have proposed a vitality mindful and layering-based grouping and steering convention (EA-CRP) for social occasion information in WSNs. The EA-CRP is utilized to decrease the vitality utilization among all sensor hubs in the system. EA-CRP utilizes an imaginative multilayered engineering. The field into various layers where the width of a layer diminishes towards the base station, yet in addition is made out of a specific number of groups. The proposed structure abbreviates the correspondence separation between hubs, yet in addition diminishes the measure of correspondence overhead required for setting up groups.

Fawzy et al. [26] have proposed a fair and vitality productive MH (BEEMH) calculation dependent on Dijkstra calculation. It gives incredible enthusiasm to the lingering vitality of hubs; subsequently higher vitality hubs are solely chosen for work as transfers. The absolute vitality utilization at both TX and RX has been converged to display the heaviness of connections between hubs. Dijkstra calculation is utilized to proficiently look for the base cost way. MH conventions are presented. Both are for the most part dependent on the BEEMH calculation. MATLAB test system has been utilized to assess BEEMH in correlation with other ordinary calculations, for example, least transmission vitality (MTE), vitality sparing focused least-jump steering calculation (ESLHA), and vitality sparing focused directing calculation dependent on Dijkstra (ESRAD) under different situations of system models.

Huang et al. [27] have vitality mindful double way geographic directing (EDGR) convention for better course recuperation from steering gaps. EDGR adaptively uses the area data, lingering vitality, and the attributes of vitality utilization to settle on directing choices, and progressively abuses two hub disjoint stay records, going through different sides of the steering gaps, to move steering way for burden balance. EDGR into three-dimensional (3D) sensor systems to give vitality mindful directing to steering opening temporary route. EDGR shows higher vitality effectiveness, and has moderate execution enhancements for system lifetime, bundle conveyance proportion, and conveyance delay, contrasted with other protocols.

Hawbani et al. [28] have proposed zone probabilistic directing (ZPR) in light of an appropriated probabilistic and randomized any cast steering convention. In ZPR, The sending likelihood conveyance is characterized by increasing the four likelihood appropriations (4PD) in particular: bearing, transmission separation, opposite separation and leftover vitality. These likelihood dispersions are totally controllable by means of a lot of exponential control-parameters. This arrangement of parameters is client situated and can be changed before hubs organization to accomplish various exhibitions. The ideal qualities for these exponential control-parameters have been acquired to meet diverse execution prerequisites as far as vitality utilization, vitality adjusting, organize lifetime and deferral.

Si et al. [29] have proposed a half and half backpressure gathering convention (Hybrid-BCP) to effectively gather information from sensors in intra-vehicle systems. Half and half BCP is in reverse good with the CAN transport innovation, and expands on the BCP convention, intended for remote sensor systems. A glorified rendition of Hybrid-BCP is utilized accomplishes ideal throughput. CAN and ZigBee handsets, exhibits the heap adjusting and steering functionalities of Hybrid-BCP and its versatility to DoS assaults and remote sticking assaults. The ns-3 test system and dependent on genuine intra-vehicle RSSI follows, that look at between the exhibition of Hybrid-BCP and a tree-based information accumulation convention

Hawbani et al. [30] have proposed a convention that consolidates Candidates Zone (CZ) by a customary geometric state of four corners. The bundles produced by the hub will be directed through any way inside the CZ. The hubs inside the CZ are permitted to be chosen as competitors. The capacity of CZ is strained by system thickness. The up-and-comers inside the CZ are organized dependent on the OR metric, which is characterized as the augmentation of four-appropriations: heading dissemination, transmission-separation dispersion, opposite separation conveyance and lingering vitality circulation.

3. Problem methodology and system model

This section explains about problem identification of existing routing protocols of WSNs and issues, then the solution of respective problems and the proposed system model.

3.1 Problem methodology

Tomar et al. [31] have introduced the Energy efficient gravitational search algorithm (GSA) and Fuzzy depending grouping along Hop include routing protocol depends on WSNs. At first, CH is chosen utilizing GSA, in view of its weight sensor hubs are joined to the CH and in this manner group is shaped. Among the chose CHs in the system, super group head (SCH) is chosen utilizing a fuzzy inference system (FIS). This chose SCH assembles the information bundle from all CHs and advances it to the sink or base station. For transmission, the effective course is set up dependent on the jump tally of the sensor hubs. The exhibition of this proposed GSA-FCR has been assessed as far as vitality effectiveness, conveyance proportion, deferral, drop and throughput and has been contrasted and that of existing plans, for example, GECR and PSOCR. WSNs have immense number of uses out of which military objective following and observation. Notwithstanding, from [21]-[31] sensors work on constrained power assets; in this manner, using those assets has brought the consideration of flow specialists. The greater part of the current works characterize arrange lifetime as when the main sensor hub debilitates the majority of its vitality. In any case, such time isn't really significant. This is on the grounds that when a sensor hub kicks the bucket, the entire system is probably going to work appropriately. To conquer those issues,

1. We propose a trusted cluster based energy and lifetime aware routing (TCELR) protocol for WSN using hybrid bird swarm-differential search algorithm. In TCELR protocol, initially we introduce a chaotic bird swarm optimization (CBSO) algorithm for cluster formation.

2. Second, we illustrate the improved differential search (IDS) algorithm to compute the trust degree of each client in the cluster. The highest trust node is considered as cluster head (CH) in the cluster and it is act as sink node of cluster members to perform intra cluster routing.

3. Finally, a scatter search based decision making (SSDM) algorithm is used for inter cluster routing to forward sensed data between different clusters. The performance of the proposed TCELR protocol is analyzed and the results are compared with the existing state-of-art routing protocols in terms of throughput, network lifetime, end to end delay, packet delivery ratio, packet loss rate and jitter.

3.2 System Model

The proposed TCELR scheme is shown in below figure. Initially, the sensor nodes are form the clustering using of proposed chaotic bird swarm optimization (CBSO), then we choosing the cluster head and source. Here, we choosing the cluster (CH) based upon which node has high trust values. We choose the cluster head using proposed improved differential search (IDS) algorithm. Then we form intra clustering routing of cluster members and cluster head (CH), intra clustering routing means the data transmission between cluster head and cluster members (node) within the one cluster group. Then, we using the scatter search based decision making (SSDM) scheme, we done the inter cluster routing for forwarding the sensed data from sink node, the sensed data forwards source to each cluster head to sink node. Here sink node act as destination.

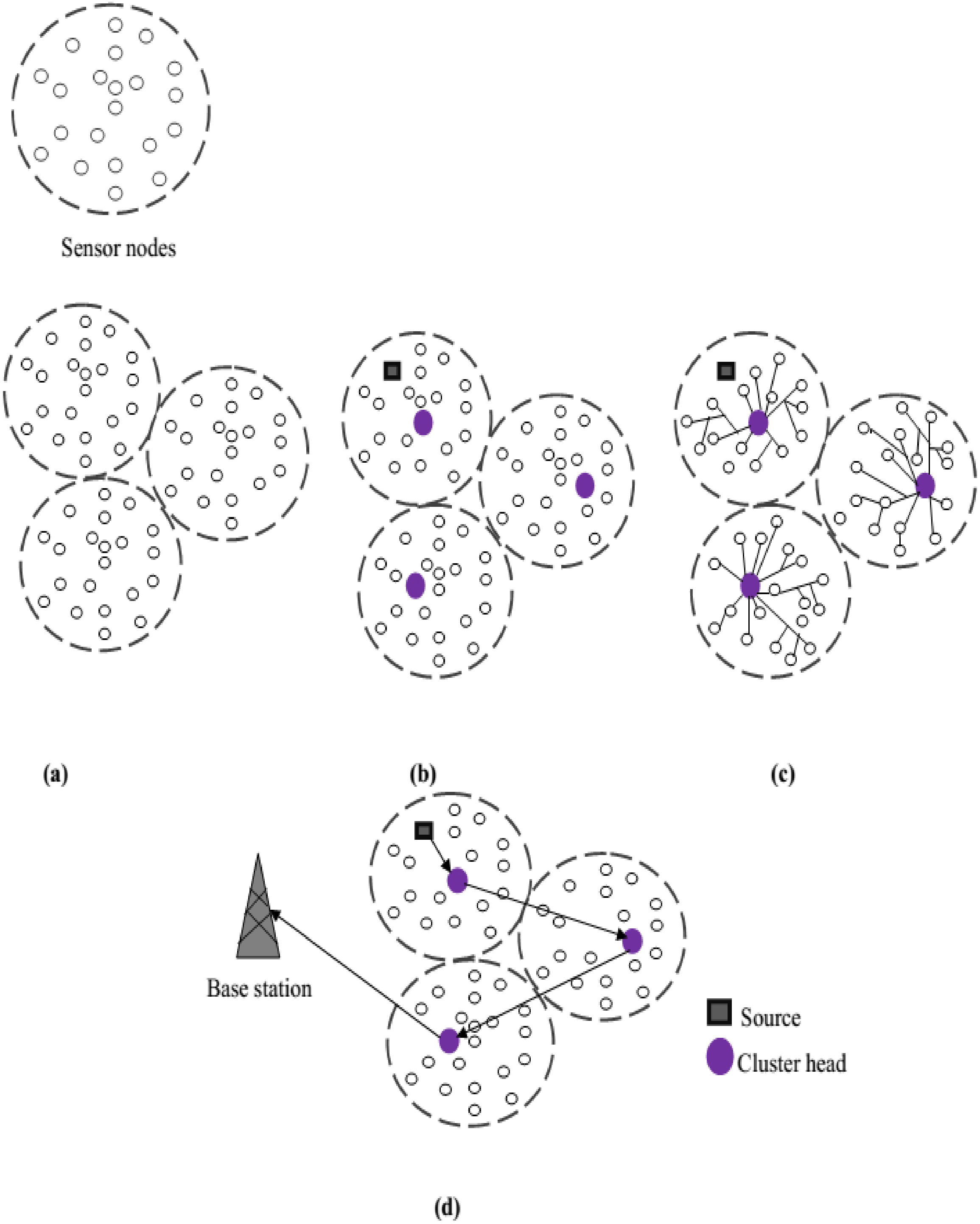

Fig.1 Proposed TCELR protocol (a) Cluster formation using CBSO (b) Cluster head selection using IDS (c) Intra cluster routing using IDS (d) Inter cluster routing for forward sensed data utilizing SSDM.

4. Trusted cluster based energy and lifetime aware routing protocol for wireless sensor network using hybrid bird swarm-differential search algorithms (TCELR)

4.1 Cluster formation using chaotic bird swarm optimization algorithm (CBSO)

Chaotic bird swarm optimization algorithm is one of the metaheuristic algorithms. It is based on simple bird's behavior, the initial position of this algorithm is represents normal bird behavior and final stage of this algorithm is represents chaotic bird behaviors. The initial behaviors are three types, foraging behavior, Flight and Vigilance Behavior. The behaviors of chaotic bird optimization is described in following equation,

Step 1. Initializing the parameters

We initializing the parameters of algorithms; the position of virtual birds is depicted $X_n{}^t\left(i \in [1,...N]\right)$ at time step t; D is dimensional space of forage food and fly.

Step 2. Initializing the population

Choose the individuals as well the global optimal are randomly and initialize the population with help of following equation, this equation is also called chaotic mapping.

$$\lambda_{n+1} = \eta \times \lambda_1 \times \left(1-\lambda_1\right) \tag{1}$$

The is initial mapping behavior of birds is λ and which is described $\lambda \in [0,1], n = 0,1,2...$ and μ is in [1, 4]. if λ the near the average distribution of among 0 to 1, at μ is closer to 4, then the system is completely chaotic.

Step 3. Updating the population

Here, we update the optimal individuals to predict the current global optimal threshold. This step can understand help of following equations,

$$X_{n,m}^{t+1} = X_{n,m}^{t} + \left(P_{n,m} - X_{n,m}^{t}\right) \times C \times ran(0,1) + \left(P1_{n,m} - X_{n,m}^{t}\right) \times S \times ran(0,1) \tag{2}$$

This behavior is also known as forging behavior, Where, The social and cognitive accelerated coefficients are represented C and S. n-th bird best past position is represents $P_{n,m}$ and sharing of past position of swarm of birds is $P1_{n,m}$.

$$X_{n,m}^{t+1} = X_{n,m}^{t} + A_1\left(mean_j - X_{n,m}^{t}\right) \times ran(0,1) + A_2\left(Pk1_{,m} - X_{n,m}^{t}\right) \times ran(-1,1) \tag{3}$$

$$A_1 = a_1 \times \exp\left(\left(-\frac{P_{fit}}{sum\ fit + \varepsilon} \times N\right)\right) \tag{4}$$

$$A_1 = a_2 \times \exp\left(\left(-\frac{P_{fit} - P_{fit}}{\left|P_{fit} - P_{fit_1}\right| + \varepsilon}\right) \times \frac{N \times P_{fit1}}{sum\ fit + \varepsilon}\right) \tag{5}$$

a_1 and a_2 are constants in [0, 2] and smaller constant ε.

Step 4. Generating the temporary population

For calculating the fitness function, we can generates the temporary population, by using of following equations,

$$V_n^{t+1} = X_{r_1}^t + F \times \left(X_{r_2}^t - X_{r_1}^t \right) \tag{6}$$

The randomly selecting three different individuals are X_1, X_2, X_3 and F is scaling factor. There is r_1, r_2, r_3 different from i.

$$U_n^{t+1} = \begin{cases} V_{n,m}^t, ran(0,1) \le CR \; or \; j = ran(1,n) \\ X_{n,m}^t, ran(0,1) > CR \; or \; j \ne ran(1,n) \end{cases} \tag{7}$$

Where CR is in [0, 1]

Step 5. Comparing the population

We compare the temporary population with original population with following formula (8) and do the next optimal iteration.

$$X_n^{t+1} = \begin{cases} U_{n,m}^t, \; f\left(U_{n,m}^t\right) < f\left(X_{n,m}^t\right) \\ X_{n,m}^t, \; f\left(U_{n,m}^t\right) \ge f\left(X_{n,m}^t\right) \end{cases} \tag{8}$$

Step 6. Find final new fitness value

We can combine and evaluates the new fitness values, and global optimal, which can be represented by following equations,

$$\begin{aligned} X_{n,m}^{t+1} = X_{n,m}^t + \left(P_{n,m} - X_{n,m}^t\right) \times C \times chaotic(map, range) + \left(P1_{n,m} - X_{n,m}^t\right) \\ \times S \times chaotic(map, range), \end{aligned} \tag{9}$$

$$\begin{aligned} X_{n,m}^{t+1} = X_{n,m}^t + A_1\left(mean_j - X_{n,m}^t\right) \times chaotic(map, range) + A_2\left(Pk1_{,m} - X_{n,m}^t\right) \\ \times (2 \times chaotic(map, range) - 1) \end{aligned} \tag{10}$$

The process of chaotic bird swarm optimization algorithm is represents in flowchart in following figure .2,

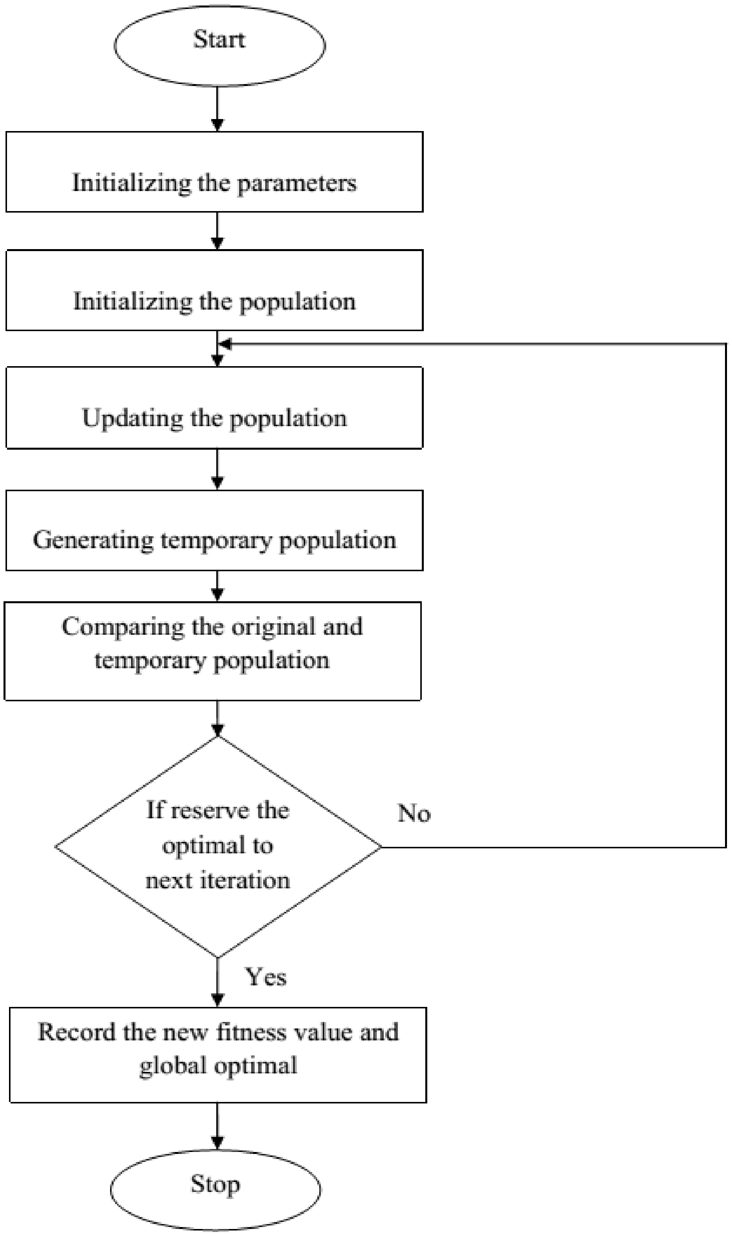

Figure 2. Process of CBSO algorithm

4.2 Cluster head trust degree computation using improved differential search algorithm

The improved differential search algorithm solves many real world problems, solution of highly nonlinear, multimodal and multivariable optimization problems. In this ISA, the main objective is producing target vector and difference vectors with using of cross over, mutation and selection vectors for producing new population. Here, we can get the mutant vector through the mutation process occurs on current population. This process is represented as following equation,

$$V_i, g = X_{R1,g} + F\left(X_{R2.g} - X_{R3,g}\right) \tag{11}$$

The current population is represented by following equation (12),

$$V_{i,g} = X_{i,g} + F\left(X_{R1.g} - X_{i,g}\right) + F.\left(X_{R_2,g} - X_{R_3,g}\right) \tag{12}$$

Where, random integers $R_1, R_2, R_3 \in [1,....., NP]$ are selects $R_1 \neq R_2 \neq R_3$. The different evolution amplification is represents F. on generation g, the best individual vector is X_{best} , The we can improve the algorithm based upon the search,

$$S_i, g = X_{R1,g} + scale.\left(X_{R2.g} - X_{R3,g}\right) \tag{13}$$

The current population of scale vector using individuals represented by following equation (14),

$$S_{i,g} = X_{i,g} + ran\ .\left(X_{R1.g} - X_{i,g}\right) + Scale.\left(X_{R_2,g} - X_{R_3,g}\right) \tag{14}$$

Where, individuals of artificial-organisms where changing size and position is controls by scale vectors. Each scale having some values, these values are may changing depends upon population and random process,

$$Scale1 = rang(2 * ran) * (ran - ran) \tag{15}$$

$$Scale\,2 = rang(3 * ran) * (ran - ran) \tag{16}$$

$$Scale\,3 = rang(4 * ran) * (ran - ran) \tag{17}$$

4.2.1 Computation of Fitness function

For assess the quality of every individual, we can using fitness function. we define the fitness function depends on constraints violation and optimization goal , the fitness function is defined by using of following equation (18),

$$fitness\ function(X_i) = \begin{cases} F(X_i, l_t + 1) & if\ vcons(X_i \\ -\dfrac{1}{vcons(X_1)} & otherwisw \end{cases} \tag{18}$$

Here, the amount of constraints violated by individual X_i. So, the fitness values will be larger, when multiple constraints violates by individuals.

4.2.2 Operators of IDSA

Stopover site is essential function of IDSA, we can search and modify the some individual's dimensions and explores the new search area. For avoiding the blind search, we can adding the information from original heuristic information from the stopover site operation, it can be represented as following equation (19),

$$\mathit{OptimizationDirection} = \mathit{Currentoptsolution} - \mathit{subopt\,solution} \tag{19}$$

Current optimal solution is represents $\mathit{currentopt\,solution}$ and current sub-optimal solution is represents $\mathit{subopt\,solution}$.

An improved stopover site generating operation is represented as following equation (20),

$$X_i = X_i + F(V_i - X_i) + w.\begin{pmatrix} \mathit{currentSolution} \\ - \mathit{subopt\,solution} \end{pmatrix} \tag{20}$$

Where, the weight parameters are w and F, which is indicates the features of random searching and directed searching. V_i Represents the individuals generated based on different methods.

The pseudo-code description of improved differential search algorithm is following,

pseudo-code description of Improved Differential Search Algorithm

```
Input    $X_{cn}$ = Current iteration number.
         $X_{\min}$ =Maximum iteration number
         $S_{spo}$ =Size of super organism.
         $S_{\dim}$ =dimension of individuals
Output   fitnessmin:the fitness value of optimal individuals
Begin    $X_{cn} \leftarrow 0$;
         $\mathit{Fitness}\ \min \leftarrow 0$;
         $\mathit{Superorgnism} \leftarrow \mathit{gen}_{spo}(S_{spo}, S_{\dim})$;
         $\mathit{fitfn\_Superorgnism} \leftarrow t\arg et(\sup \mathit{erorganism})$;
         optdirection=<0,0,…,0>
         for $X_{cn}$=1: $X_{\min}$ do
             individual ← genindi(method, superorganism, fit_superorganism, $S_{spo}$);
             stopover ← gensite(optdirection, superorganism, individual);
```

```
        fit_stopover ←target(superorganism);
    if  fit_stopover < fit_superorganism then
        fit_superorgnism ← fit_stopover;
        superorganism ← stopover;
    Endif
    if    fit_superorgnism<fitnessmin then
          fitnessmin fit_ ←superorganism;
          suboptimal ←globalmin;
          globalmin ← superorganism(fitnessmin);
          calculate optdirection
```

End

```
        Endif
endfor
output globalmin and fitnessmin;
```

4.3 Inter cluster routing using scatter search based decision making (SSDM) algorithm

4.3.1 Scatter Search Approach

Scatter search algorithms are one of the heuristic algorithm, which is solves the difficult optimization problems, There are five parameters having this algorithm, each framework acquire individual behaviors. They are diversification generation; reference set update method and solution combination method, solution improvement method, subset generation.

Diversification Generation Method:

This method is revolving around the different course of action over the randomization. At this stage, we present the population. Here the DGM (Diversification Generation Method) is intentional, not sporadic procedure, which is makes the different sets for stages, which is described as vectors,

$$V(h,w)=(u,u+w,u+2h,.....,u+rh) \tag{21}$$

Here, $w,u,r \in N \setminus \{0\}$ positive integers.

Reference Set Update Method:

This RSUM important structure for SSA we can improve and continue the search process with intensity and diversity using of this RSUM method. Also this parameter of scatter search is maintains the best solutions and best fitness values. The size of reference set is defined as,

$$be_1 + be_2 + be_3 = |refset| \tag{22}$$

Here, be_1, be_2, be_3 are best solutions choosing from function value of objective.

Solution Combination Method:

This method is used for creates subset of reference sets. Which is selects the correct ways and combination of refset 1 and refset 2 in combination of every iteration. For example, $refset1 = \{S_1, S_2, S_3\}$ and $refset2 = \{S_4, S_5, S_6\}$.

Subset Generation:

In these criteria, we creates the subsets with different sizes. There are following types of subsets available, Type 1: each two element subsets, Type 2: three element subsets which is derived from two element subsets. Type 3: four elements subsets, which are augmenting from three element subsets. Type: 4 the subsets having I elements.

The algorithm of Scatter Search is following,

```
Algorithm 1   Scatter Search
Input         Population of the problem
Output        Best solution
Step 1        Initialize the population using DGM
Step 2        Apply the IM method to the population
Step 3        Update the RSUm
Step 4          while (itr<maxitr) do
Step 5            while (reference set is modified) do
Step 6                Subset Generation method
Step 7                    While (subset-counter< >0)do

Step 8        Update SCM
Step 9        Update SGM
Step 10       Update RSUM
Step 11                 end while
Step 12           end while
Step 13       end while
Step 14       Return best solution
```

4.3.2 Decision Making Algorithm

The decision making algorithm is used for solves the optimal ranging problems and multi processor clock synchronization, health monitoring, computer networking structures. Also this algorithm having some specific rules. which having some specific agents and local interactions and actions. This algorithm has following factors, Decision Horizon (DH), Maximum Number of Alternatives (MNA) and Sampling Rate (SR). These factors are using for implements this algorithm. Which have following,

Find the MNA:

we initializing the population or root for corresponding every clusters until till the maximum number of alternative (MNA) and decision horizon (DH) have been come to.

Generate the SR:

For each clustering head (CH) we do the first stage and generates the sampling rate (SR test) arbitrarily relegating assets to tasks up till every cluster head of specific group have been looked.

Compute the corresponding values:

For every cluster having to same alternative with Stage 1, we compute the corresponding values. and finding the estimations of each cluster using following equations (23), (24), (25),

$$\hat{C}A_{ij} = \frac{CA_{ij} - CA_j^{\min}}{CSA_j^{\min} - CA_j^{\min}} \tag{23}$$

$$U_i = \sum_{j=1}^{n} w_c \hat{C} o_{ij} \tag{24}$$

$$\hat{C}A_{ij} = \frac{CA_{i,j}^{mx} - CA_j}{CSA_j^{\max} - CA_j^{\min}} \tag{25}$$

Where CA $_{ij}$ is consequence appraisal with alternative I belongs to criterion j, is standardized appraisal of CSA $_{ij}$ and quantity of alternatives represents m. W_c is the criterion's weight factor.

Finally, we choose the alternative along the maximum utility estimation. Then Stores the assignments (find the MNA) of choose alternatives. Otherwise repeats the initial to final stages till each CH choosing the each grouping.

5. Result and Discussion

The Network Simulator (NS2) is used to simulate the proposed trusted cluster based energy and lifetime aware routing (TCELR) protocol for WSN using hybrid bird swarm-differential search algorithm. The analysis of routing protocol is analyzed by various testing scenarios with varying number of nodes and rounds. The proposed trusted cluster based energy and lifetime aware routing (TCELR) protocol technique for WSN using Chaotic Bird Swarm Optimization (CBSO) Algorithm, Improved Differential

Search (IDS) Algorithm, and Scatter Search based Decision Making (SSDM) Algorithm. The Chaotic Bird Swarm Optimization and Improved Differential Search algorithm were compared with existing Gravitational Search Algorithm (GSA), super cluster head (SCH), fuzzy inference system. our proposed model evaluated enormous loads. Here, we using the 400, 600, 800, 1000 and 2000 nodes are randomly performed by the simulator. The nodes are performed on 1000m×1000m network areas. Here, the sensor nodes are clustering form using an chaotic bird algorithm and using of improved differential search algorithm, the signal is forwarding the cluster head, Moreover, the sensed signal is forwards the source to sink node.

During this process, the constraints of sensor nodes parameters performance analysis the following graph.

Table .1 Network Simulators of TCELR Settings

Parameters	**Value assigned**
Number of nodes	400, 600, 800, 1000 & 2000
Routing protocol	TCELR
Antenna	Omni antenna
MAC version	802_11
Packet size	512 bytes
Simulation time	60.000000
Rate of data	500 kb
Initial transmitting & receiving power	0.660w & 0.395
Network area	1000m×1000m
Radio Propagation model	Two ray ground

5.1 Performance Analysis

5.1.1 Throughput:

Throughput is described as, the throughput ratio defines the rate of data packets accepted at a destination according to the number of packets generated by the source node for a specified period of time.

$$Throughput\ Ratio = \frac{\mathrm{Re}ceived\,Data\ *8}{Data\ Transmission\ Period}$$

From fig.3, clearly analyze the through put is increases, (TCELR) slightly than the existing method GSA-FCR. From this analysis, the using proposed TCELR, through put ratio is increases and improved. Here, for 600 workloads, corresponding through put value is 43. for 700 workloads, through put value is increased 48 and 800 workloads increasing the through put 53. For 900 workloads, corresponding through put value is 57. For 1000 workloads, through put values is increase 64. Comparing with existing method, the throughput increased and improved using proposed TCELR protocol.

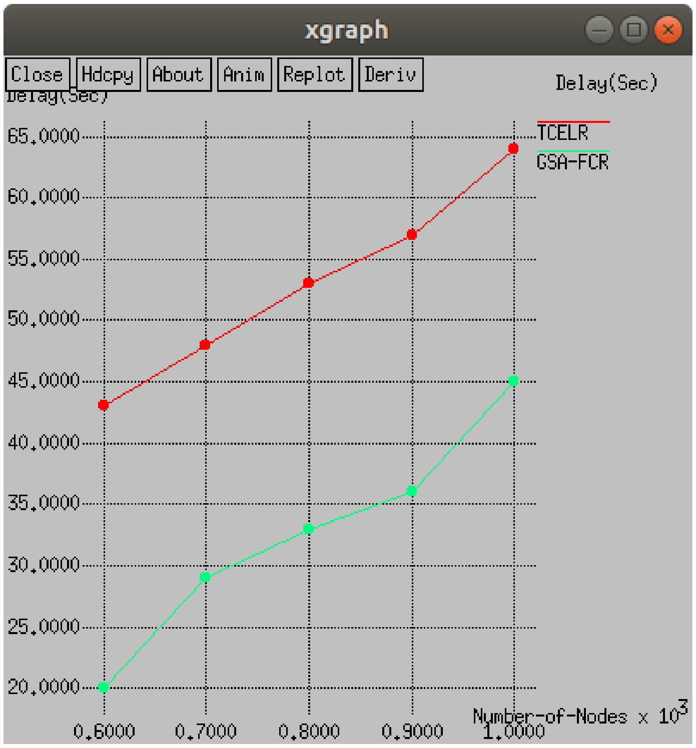

Figure 3. Number of workloads versus throughput

5.1.2 Network lifetime:

It is defined as, it is period of time, which is the energy runs out from the initial sensor. It is an important property of wireless sensor networks. Here, for 200,400,600,800,1000 workloads corresponding network life time is 50,45,42,39,37. When the loads increases, the corresponding network lifetime also increase. From the figure 4, the network life time is increases 80% to 90% using of proposed TCELR.

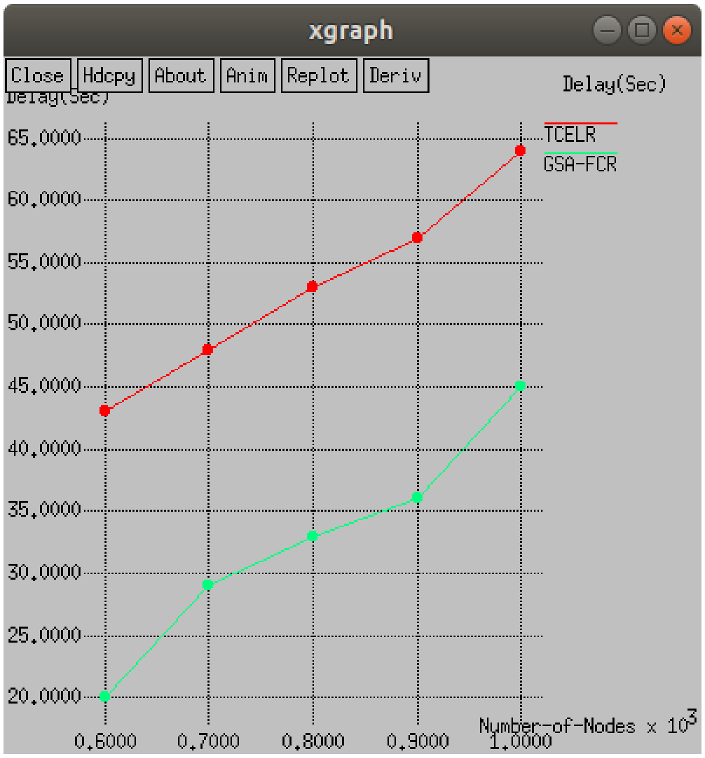

Figure 4. Number of workloads versus Network life time

Comparing with existing method GSA-FCR, the network lifetime is increase in our proposed TCELR method.

5.1.3 End to end Delay:

The one way delay or delay is defined as, the time receive from the packet transmitted from source to destination across the network. It can be represented by following formula,

$$End\ to\ end\ delay = \frac{N * L}{R}$$

N is represented link in series, which is used for forwarding and storing the links. R is transmission rate and L is packet length. There workloads are 200,400,600,800,1000 and corresponding delay values are 30,27,25,23,22, when workloads values are increases, corresponding delay values decreased from fig. 4, the delay is minimized by using of proposed TCELR. Comparing with existing methods, the delay is decreased rapidly

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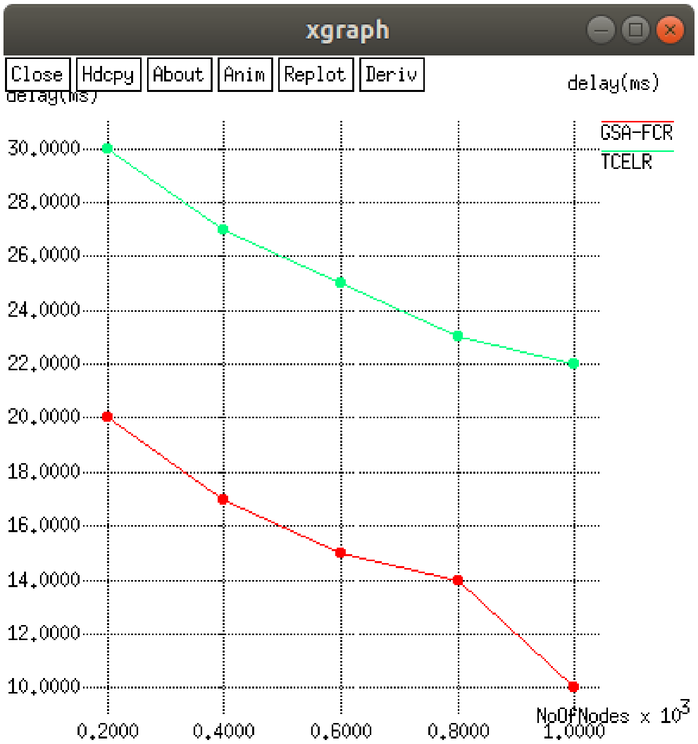

Figure 5. Number of workloads versus Delay

5.1.4 Packet Delivery Ratio:

The ratio among the packets received by destination and packets generated by the source.

$$PDR = \frac{\text{Re}\,ceived\,Packets}{Generated\ Packets * 100}$$

Where, packet delivery ratio is increased 99%, by using of proposed TCELR protocol. For given 200, 400, 600, 800, 1000 workloads, the corresponding PDR values are initial PDR value is 70,72,81,89 and final value of PDR is 90. Comparing with existing method GSA-FCR, the improved and higher packet delivery ratio (PDR) is provided by proposed TCELR.

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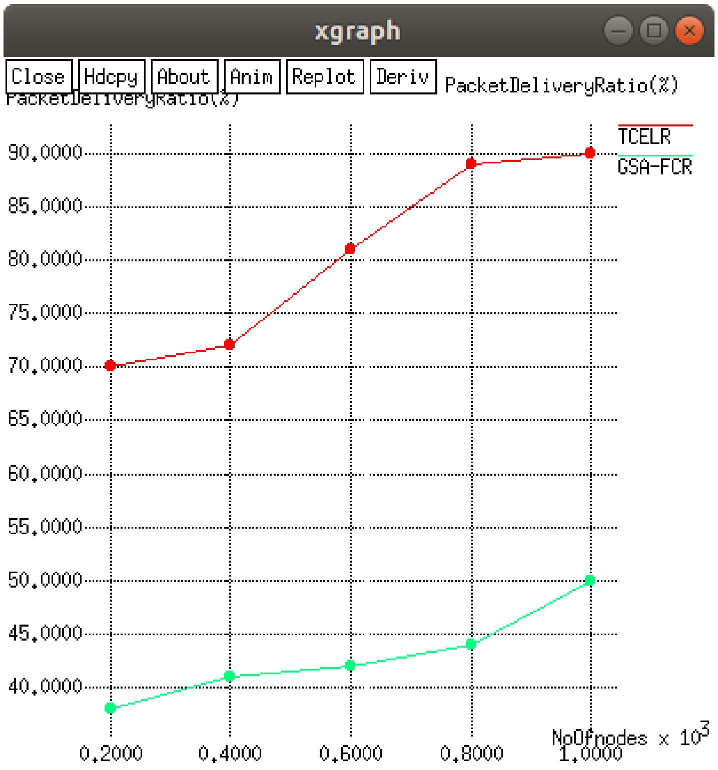

Figure 6. Number of workloads versus Packet delivery ratio

5.1.5 Packet loss:

The network fails to reach the destination, during more than one packets travelling. This is known as packet loss. The packet loss is may induced by errors in network congestion and data transmission.

$$Packet\ loss = \frac{no.\ of.\ received\ Packets\ not\ received}{Total\ no.of\ .\ packets}$$

Initially, the packet loss value is 45% for 200 workloads. Finally increases 72% for 1000 workloads. For 400, 600, 800 workloads corresponding maximized packet loss values are 47, 55, 63. From analysis of fig.6, the packet loss of proposed protocol is increases the 90% increases than existing GSA-FCR.

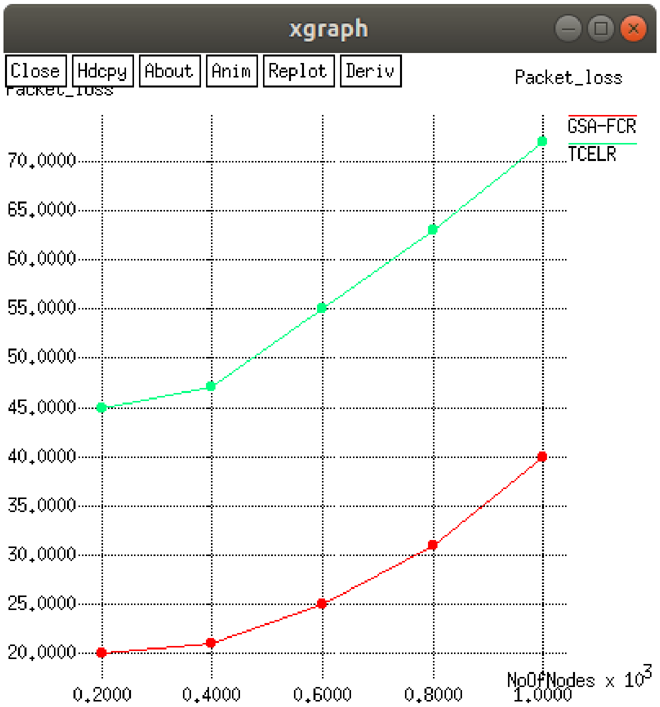

Figure 7. Number of workloads versus Packet loss

5.1.6 Jitter:

It is also known as packet delay variance. The variance of time delay in milliseconds (ms) among the data packets over a network. The jitter can be calculated by following formula,the jitter values are increased 40, 50, 51,59 also 64 for inputs as well as workloads 200, 400, 600, 800, 1000. From fig.7, the jitter or packet delay variance is increased.

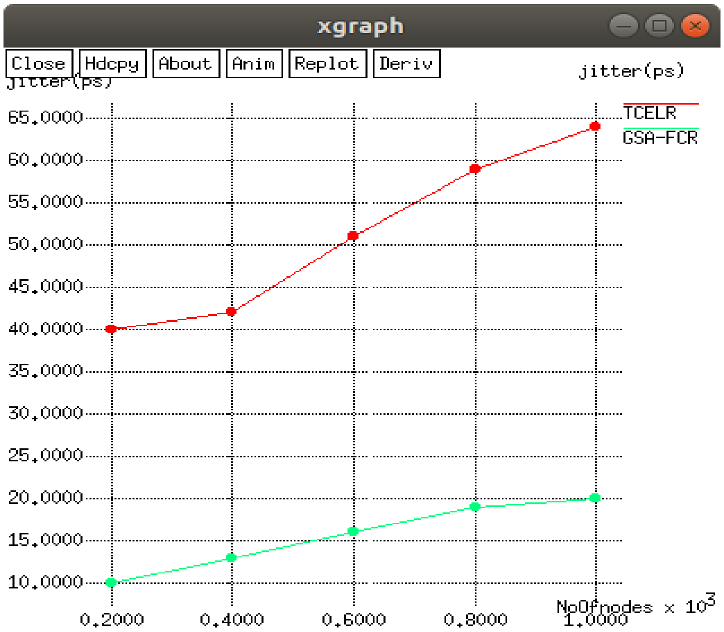

Figure 8. Number of workloads versus Jitter

. Where, the jitter is slightly maximized from 50% to reach the 90% contrast with the existing GSA-FCR

6. Conclusion

We propose a trusted cluster based energy and lifetime aware routing (TCELR) protocol for WSN using hybrid bird swarm-differential search algorithm. By using of proposed Chaotic Bird Swarm Optimization (CBSO) Algorithm, we clustering the every node and compute the trust degree of every clients of cluster, by using of Improved Differential Search (IDS) Algorithm. Then we computes the highest trust node (cluster head (CH)) and performs intra cluster routing for forward sensed data among the different clusters, by using of Scatter Search based Decision Making (SSDM) Algorithm. The result and performance analysis out of proposed TCELR gives high efficiency and reduce the barriers of existing methods comparing with the existing state-of-art routing protocols in terms of throughput, network lifetime, packet loss rate packet delivery ratio, and end to end delay, jitter.

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