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ISSN: 0193-4120 Page No. 3138 - 3153

An Energy Efficient Routing in Smart Grid Wireless Sensor Networks based on HSA-MPSO Algorithm

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Article Info
Volume 83
Page Number: 3138 - 3153
Publication Issue:
March - April 2020

Article History
Article Received: *24 July 2019*
Revised: *12 September 2019*
Accepted: *15 February 2020*
Publication: *21 March 2020*

Abstract:
In modern era, energy utilization is a serious problem in wireless sensor network. It is proposed that the usage of power is powerfully balanced with the high searching capability of Harmonic Search Algorithm (HSA). Though, centrality in finding the route is measured as an utmost dispute in finding the essential node in WSN, thus, the Shortest Path Operator Calculus Centrality (SPOCC) is utilized to optimize the centrality harms in routing. The SPOCC locates the main routing path using HSA and high centrality node is estimated by Modified Particle Swarm Optimization (MPSO) algorithm, so guarantee best possible routing with reduced power consumption. Introduction of MPSO improves the life span of nodes with its dynamic capability. The proposed hybrid algorithm result has been evaluated by means of the various result metrics like Packet Delivery Ratio(PDR), average End-to-End Delay, throughput and average residual power in smart grid outdoor transmission environment and the result shows the proposed hybrid algorithm attain enhanced progress in terms of reduced delay and high residual power than the existing algorithm.

Keywords: *Shortest Path Operator Calculus Centrality, Harmonic Search Algorithm, Modified Particle Swarm Optimization.*

I. INTRODUCTION

Web of Things and administrations are firmly identified with assembling parts which prompts the fourth phase of modern upheaval for example Industry 4.0, a computerized period is said to be quick drawing nearer. This should be the developing pattern among the enterprises and it increases significant consideration from the makes, specialists and designers among various spaces. This progressive industrialization changes over the businesses brilliant enough by coordinating the whole procedure by associating all the physical gadgets through a typical system. In Industry 4.0, the associated gadgets are normally situated at far off areas and crosswise over different businesses, which connects with one another through a typical convention. This ought to anticipate well the disappointments, adjust changes and arranges them. This has changed the remote sensor systems to work under the standards of web of things. At present, the associated gadgets inside the manufacturing plant impart utilizing remote modules and streamlining the administration activities with significant unique reconfigurable components is consequently important. It reinforces the controlling activities and the executive's abilities identifying with mechanical components. In such respects, the modern remote sensor arrange is considered as an unavoidable innovation for discharging the vision of industry 4.0 [18], particularly in the fields of keen matrix organization. Since, it offers recognizable proof, detecting, handling and systems administration abilities requiring little to no effort. So as to accomplish certain targets by a PC put at remote spot, virtual layer gave by the sensor organize in regards to the physical manufacturing plant is viewed as valuable. This empowers expanded monetary advantages and improves the unwavering quality of mechanical creation and maintains a strategic distance from the breakdown and diminishes the support cost. The modern unrest utilizing web 4.0 assumes a significant job in the fields of transportation, farming, social insurance and so forth. WSN in these fields keep up the throughput, unwavering quality, and versatility, organize lifetime and increment inclusion with diminished inactivity [11]. The reconciliation of electric power segments with proficient conventions prompts compelling creation and inventive administrations to the world [12]. Consequently, the utilization of WSN improves the quality, creation, adaptability and establishment with diminished use [13]. The significant downside behind the arrangement of remote sensor organize in the acknowledgment of savvy lattice application is its unwavering quality and effectiveness of correspondence among the system. The information is transmitted between the sensor hubs to arrive at the goal through a typical correspondence convention. It underpins well the multi-bounce situation of spread WSNs with steering calculation and information conveyance conventions, which conveys the detected information with decreased utilization of vitality. Such request in the field of electrical and computerization industry requires the need of new noteworthy necessities that ensures decreased start to finish delay, expanded conveyance proportion over obliged arrange data transfer capacity. Be that as it may, confinements or difficulties influences the QoS necessities, which should bolster multi-class traffic, excess, vitality exchange off, clog and multi-way steering [5]. Additionally, the remote channels will in general experience related with electromagnetic obstruction, hardware clamor and multipath blurring [11]. These most likely decreases the quality inconsistencies among the remote connections and makes the information transmission a difficult one. Thus WSN in mechanical mechanization should focus on giving connection quality better information conveyance for achieving the necessity like throughput, unwavering quality, versatility, arrange lifetime and idleness. In particular centrality of hub is a biggest test in assessing the hub measurements of an auxiliary diagram. It measures or gauges the significance of a sensor hub. It is further for enhancing the directing issues for finding the primary way with high centrality hubs in WSN. The significant issue while finding the centrality of hubs is the expanded utilization of hub vitality for all figuring purposes. Centrality is the idea of deciding the significant hub in WSN by figuring the briefest way that crosses a specific hub. So as to stay away from the utilization of vitality by the focal hubs, the creators propose a most brief directing way utilizing HSA-MPSO Algorithm. The primary commitments of this paper are recorded underneath, In this paper, the utilization of vitality is effectively adjusted utilizing the high looking through capacity of Harmonic Search Algorithm (HSA). Be that as it may, hub with most brief way steering is considered as a most extreme test in finding the significant hub in WSN. Thus, Shortest Path Operator Calculus Centrality (SPOCC), which is enlivened from [19] is utilized to advance the centrality issues in steering. The SPOCC finds the fundamental directing way utilizing HSA and high centrality hub is evaluated by Modified Particle Swarm Optimization (MPSO) calculation, in this manner guaranteeing ideal steering with decreased vitality utilization. The usage of MPSO improves the lifetime of hubs utilizing its dynamic ability.

a) The MPSO algorithm underpins HSA calculation with its dynamic nature to builds the lifetime of the system. The cross breed calculation is joined with Shortest Path Operator Calculus Centrality (SPOCC). The SPOCC maintains a strategic distance from the centrality issue in WSN and guarantees better steering with HSA-MPSO.

b) The SPOCC is assessed as pursues: For each pair of vertices, the ideal ways are determined between them, for this situation the complete limit of vitality and the base of Bit Error Rate (BER).

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The framework of the paper is composed as pursues: The accompanying Segment 2 gives the traditional plans identified with the present theme exchange. Segment 3 talks about the proposed SPOCC and segment 4 with half and half HSA-MPSO calculation. Area 5 examines the system model. Segment 6 assesses the proposed strategy with ordinary calculations. Segment 7 finishes up the paper with future bearings.

II. RELATED WORKS

A few systems are exit to lessen the utilization of vitality in WSN. Different most brief way calculations are in presence to lessen the most brief way calculation in brilliant matrix WSNs, some of which are given here. Yigit et al. [1] proposed interface quality-mindful and channel-mindful multi-direct planning calculation in savvy network applications. This investigation address the worries identified with limit and deferral for different traffic loads. The conditions are reproduced under high and low traffic load. Certain reproduction parameters identifying with the present investigation is considered from this paper. Nafi et al. [2] proposed a local territory organize correspondence structure, which targets upgrading the effectiveness of savvy framework sensor connect with diminished expenses. Faheem and Gungor [3] proposed EQRP proposed EQRP with bird mating optimization to improve the steering in Smart Grid Industry 4.0 WSN. This examination diminished the start to finish delay and improved the bundle conveyance proportion, memory use, remaining vitality, and throughput. Faheema and Gungora [4] proposed information limit mindful channel task utilizing fish bone routing algorithm in smart grid applications of WSN. This framework manages dynamic exchanging between the ghastly groups to fulfill the sacristy in channel. It decreases well the bundle misfortune and improve the connection quality to improve the system lifetime in cruel smart grid environments. Li, X., et al. (2018)[20] presents a methodology on obliged improvement on multicast directing in wide zone systems with distribute buy in engineering. The obliged enhancement is hypothetically tackled with Lagrangian Relaxation.The bandwidth constrained minimum Steiner tree algorithm is utilized to actualize the engineering. Faheem and Gungor [5] proposed a multi-mobile sinks-based QoS-aware data gathering protocol (MQRP) in WSN smart grid 4.0.The investigation lessens the the packet loss, data traffic and energy consumption and latency utilization and idleness in insatiable way.Thus, other steering conventions planned to build the system lifetime incorporates follow cost based source area security assurance conspire [6], Minimum Hop Spanning Trees [7],three-phase energy-balanced heuristic[8], sub-optimal distributed control algorithm [9] and energy-efficient query technique with channel into question sub-tree [10].This examination neglected to address the irregular sending of smart grids just as tending to the centrality issue of hubs in brilliant matrix WSN. Thus, the proposed examination thinks about centrality issue and address it utilizing appropriate choice of hubs for most limited steering ways in shrewd framework WSN environment. Further, the examination utilizes meta-heuristic models to choose the briefest courses for POCC model that guarantees better choice of hubs with appropriate determination of ways.

SHORTEST PATH OPERATOR CENTRALITY CALCULUS

The proposed directing over WSN is discussed about in this segment with specific suspicions over sensor nodes and wireless sensor network, which incorporates the accompanying.

1. The sensor nodes in smart grids are conveyed arbitrarily inside the system extend.
2. It comprises of just one sink node or the Base Station (BS).
3. Nodes are sufficiently prepared to transmit the information to BS.
4. Nodes don't know about its area and the area of different notes.

5. The nodes are expected to have various capacities as far as correspondence and preparing cost, which improves the versatility of the system.

2.1 Operator Calculus Approach

The fundamental thought behind the administrator math is its more profound relationship of mathematical model and charts, where the arithmetical model uncovers the data identified with diagrams. A nil-potent adjacent matrix is considered as an arithmetical model, which gets related with limited chart structure with keeps away from cycles, ways and so forth. This stays away from self-forming graph structures utilizing the framework control calculation. The development of Grid and way inside the lattice is appeared in Figure 1.

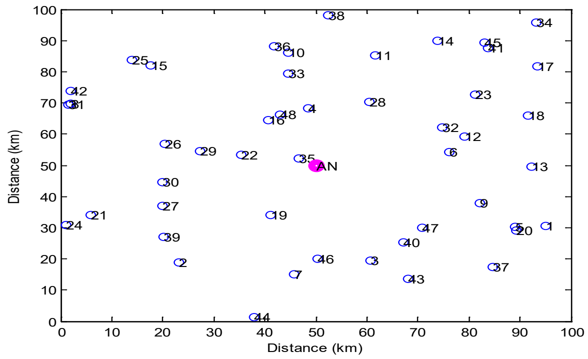

Fig. 1(a) Node placement in proposed model in simulation area of 100x100 km

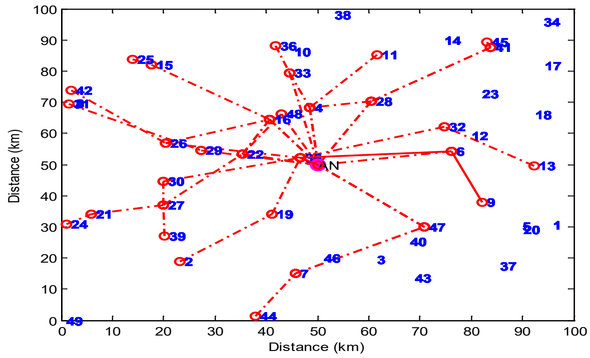

Figure 1(b). Grid formation and Path formation using SPOCC

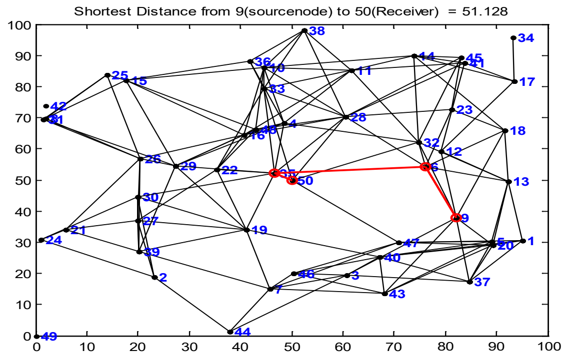

Figure 1(c). Grid formation and shortest Path finding using SPOCC

The WSN is spoken to as a chart G = (V,E) with Vas sensor nodes (SNs) set and Eas edge set. Two nodes are related through a typical edge, which are at good ways from one another or inside its correspondence go or neighboring hubs in chart. Thus, the sensor nodes communicate with one another utilizing a typical edge or a way exists between them. The every nodes pair is associated with one another through an edge, and afterward it is called as connective chart. Thus, an rooted tree structure is framed between the whole sensor node and BS, which is the root of the tree. Consider a node (w) from a node (v) on a way to the root node is considered as a predecessor of node(v).Henceforth, in the event that the node(w) is considered as a predecessor of node (v), at that point the node (v) is viewed as the relative of node (w).Along these lines in a tree structure, the node (v) turns into a parent of node (w) and the node (w) will be the offspring of node(v).This is valid if the edge (v,w) exist when d(w, sink) >d(v, sink).

The algebraic homomorphism is used to define the nilpotent adjacency matrix Ψ with constrained path (C), which is given by Eq.(1)

(1)

This leads to a full algebraic function or Dirac Notation (AC⊗ Ωn) using a linear extension, given in Eq.(2).

(2)

AC⊗ Ωn is thus extended as a linear function of (AC⊗ Ωn)|V| using Eq.(3).

(3)

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The path operator calculus centrality is utilized to gauge the ideal ways, which navigates a node. Centrality standard related with the systems is considered while ascertaining the ideal way. The node with high centrality esteem is introduced on primary way acquired from HAS-MPSO routing algorithm and it helps in setting up arrange availability. The high centrality hubs are not considered along the briefest ways and between hub sets, since the information needed to relay through the high centrality node is always high.

The SPOCC for a graph G with vertices V is assessed as pursues,

 The ideal ways are assessed utilizing HAS-MPSO calculation over every vertices pair (s,t), where the all-out vitality of the node is accepted most extreme and bit error rate is expected least.

 The portion of ideal way is characterized over every vertices pair (s,t), which navigate the vertex v.

- At last, the whole portion of ideal ways are added over vertices pair (s,t). For comprehension, it is accepted as pursues
- The base station (BS) is situated at the system focus.
- Sensor nodes (SN) have distinctive piece mistake rate and vitality level.
- The communication range (Rc) and sensing range (Rs) is same for whole SNs.
- The SPOCC calculation happens at BS.

2.1.1 Routing Strategy

Number of nodes in a network is represented to as n and these nodes are considered as switches and sensors for detecting and transferring the information parcels.The packet delivery ratio of the wireless link continues as before for singular remote connection.A reception buffer is accepted during low information rate, which procedure well and transmits the parcels in compelling way in its buffer.The information parcel is embedded at certain time intervals from the source node and consequently the system traffic runs in a discrete way.At each discrete time, a fixed routing table is utilized to transmit the information through intermediate nodes from source to sink node.The SPOCC rule is currently applied over the fixed routing table to deal with well the information crossing stage.

Consequently in the proposed technique, the SPOCC system offers various ideal ways over the grid topology from each SNs to BSs. The SNs in this way has different ideal ways with centrality scores for every node, which is put away in the routing table after legitimate characterization. This enables the whole traffic to structure in future course recuperation process.Protocol Phase

The SPOCC convention is partitioned into three stages, specifically, Grid Formation, deployment of routing and routing maintenance.

2.1.1 Random Grids Formation:

The detecting region is considered as a lattice improvement territory, where the SPOCC technique receives grid topology to send a WSN, since SNs stays with same Rc and Rs. The SPOCC convention isolates the whole detecting extent into similarly partitioned squared formed regions.Here, the SNs are situated as networks, where the nodes are put in legitimate request in a specific range. In this SPOCC model, the equivalent separating of SNs into networks frames a corner to corner way towards the BS. Additionally, the information sending happens dependent on the density of the SNs, where the density of nodes are discovered utilizing Random Direction mode [16].

The availability at networks are guaranteed, when the size of matrix (R) is same as the correspondence and detecting range for example R = Rs = Rc. This condition guarantees that the SNs are fit for setting up correspondence with different nodes in the neighboring networks.The arrangement of networks is done noticeably utilizing two sorts of nodes, to be specific, ordinary (N) hub, which is the basic hub and the propelled (A) hub, which is chosen by the BSs dependent on the scoring level of SPOCC. The fitness function of HAS-MPSO calculation finds the leftover vitality level all things considered. The nodes with vitality levels more noteworthy than 65% (an edge setting embraced in this paper) is considered as cutting edge nodes.Essentially, the hubs with vitality levels lesser than 65% are considered as would be expected nodes.This paper embraces 65% as an edge setting to isolate the progressed and ordinary hubs as far as energy of nodes.

Algorithm 1 Random Grid Formation

Data Input: Centrality Score, Assign S(i).E = E0α, where E0 is initial node energy and α is energy heterogeneity value.

Step 1:	Set up random nodes
Step 2:	for i = 1 to N do
Step 3:	Find the normal nodes
Step 4:	Allocate centrality score for individual nodes.
Step 5:	if S(i).score < Threshold
Step 6:	S(i).Score = 1
Step 7:	S(i).E= E0
Step 8:	S(i).Score='value'
Step 9:	S(i).type= 'Normal_node'
Step 10:	End
	/*Delineate Advance nodes*/
Step 11:	for i = 1 to N do
Step 12:	if S(i).Score >Edge distance then
Step 13:	S(i).Score =1
Step 14:	S(i).type='Advance'
Step 15:	End
Step 16:	End
Step 17:	End

2.1.2 Routing Establishment:

After the arrangement of the SNs, the BS appraises the centrality of every SNs dependent on SPOCC utilizing bit error rate and energy level of the SNs. The ideal way for every SNs to arrive at the sink node is by and large created by BS, since it utilizes the SPOCC run estimation. At long last, the frameworks are shaped and afterward routing establishment process gets started.

The BS contains whole data about the SNs for example it have centrality score of every hub and other asset related data. The centrality score gauges the impact of a node in a system. It allocates relative scores to all nodes in the system dependent on the idea that associations with high-scoring nodes contribute more to the score of the hub being referred to than equivalent associations with low-scoring node.The centrality score is determined utilizing. (4)

where σst–absolute number of ideal ways between the source (s) node and sink (t)node and σst(V) – complete number of ideal ways between the source (s) node and sink (t) node, while going through the moderate (v) hub. The sensor nodes are sent in arbitrary way and the size of system shows the way administrator centrality ascertains score. On the off chance that the size of the system is huge, the score stays large and the other way around. The score in irregular system is browsed the hubs in principle ways.

At that point, an arrangement message is sent by the BS to all SNs. Upon the gathering of arrangement message by the SNs, the Node_ID is checked for information trustworthiness. On the off chance that the Node_ID is bogus, the arrangement message is sent to different SNs and then again, if Node_ID is valid, the organization message is recorded alongside parent and kid hubs. The fundamental way is set up utilizing HAS-MPSO that uses the data from every single propelled hub of BS and afterward an arrangement message is multicast by BS to every propelled node. At long last, a steering way is shaped dependent on parent-kid connection between the advanced node and child node.This ensures the association of new child node with the parent node for example propelled node. The neighbors of cutting edge nodes structure the new child nodes.

Algorithm 2 Path Establishment

Step 1: While SN gets setup message from BS
Step 2: Check node id (Node_ID) do
Step 3: if the id of sensor node (Node_ID) is true then
Step 4: SN embraces the information
Step 5: SN record the child and parent node
Step 6: Else
Step 7: SN ahead the setup message
Step 8: End
Step 9: End

2.1.4 Maintenance Phase:

The idea of organization in WSN makes the support stage to be most troublesome one, in any case, it helps in reinventing the past stage and includes vulnerability utilizing expended assets. If there should arise an occurrence of node disappointment, BS gets a blunder message and a neighborhood search is performed in the routing table for the choice of cutting edge node. This reproduces another routing path.

Algorithm 3: Path recovery

Step 1: If damaged link is detected by SN AND if Data transmission is miscarried. do
Step 2: for individual S(i) do
Step 3: if S(i).E = 0 then
Step 4: if S(i).Score = 1 AND S(i).type = 'Advance_node' then
Step 5: Send BS collects error message.
Step 6: Local search is executed by HSA-MPSO to accomplish finest path
Step 7: Find new advance node
Step 8: Else if S(i).Score = 0 AND S(i).type = 'Normal_node' then
Step 9: Allocate centrality score to every sensor nodes.
Step 10: Send BS collects error message.
Step 11: Local search is executed by HSA-MPSO to accomplish finest path
Step 12: Find new normal node
Step 13: Else if S(i).Score = 0 AND S(i).type = 'Normal_node' or if S(i).Score = 0 AND
Step 14: S(i).type = 'Normal_node' then
Step 15: Go to Step 2
Step 16: End
Step 17: End
Step 18: End
Step 19: End

The perseverance or life span of the system is upheld by the upkeep stage. The absolute devoured energy during the transmission of k-bit to the target node over a separation (d) is assessed as,

(7)

where d0 is the edge distance, which is given by,

(8)

where, and are the amplifier energy to conserve the usual SNR. The Eq.(8) refers to the reference distance between the transmitter and receiver node. The consumed energy by the received k-bit information of a SNs is so given by,

$E_{RxK} = k*E_{elec}$. (9)

where, Eelec – energy consumed by two enhancer with various transmission modes.

The energy utilization is given by Eq.(7) during the hour of information transmission. it is gotten from two models, specifically, ideal transmission and multi-access interference model. The previous model has transmission separation is lesser than edge separation ($d<d0$) and the other way around in last model ($d \geq d0$).

At long last, it is expected that the every SN has a constrained ratio, which comes to with its neighboring bounce to spare energy.

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MODIFIED PARTICLE SWARM OPTIMIZATION (MPSO) ALGORITHM

Underwater acoustic multipath channels are inadequate both in time area and recurrence space [22], [23], [24] which implies that solitary a few taps are non zero in the network model and we can set L as a little optimistic whole number in (25). In this manner, just L sets of parameters should be assessed also the estimation multifaceted nature is significantly diminished. Besides, it is conceivable that those L ways be able to be recognized by means of a revised

3.1 PSO Algorithm.

Kennedy and Eberhart [26] presented PSO ALGORITHM PSO. The first aim was to graphically reproduce the effortless yet erratic movement of a feathered creature flock. The arrangement of PSO is introduced by a populace of irregular arrangements and every possible procedure is doled out a randomized speed, and the possible arrangements, called particles, are at that point "flown" through the issue interplanetary. In the issue space, every molecule refreshes its situation as indicated by two "best" values. One is simply the best arrangement has accomplished up until this point, called pbest; and the other is the best arrangement followed using entirely particles in the swarm, called gbest.

A concise prologue to the activity of the PSO calculation is as per the following. Give p a chance to indicate the quantity of particles in the swarm and every molecule's position speaks to a potential arrangement of the issue space D. At the (k +1)th emphasis, for molecule I, its position xi k+1 can be determined as pursues:

xik+1=xik +vik+1 (10)

with a pseudo-velocity vi k+1 estimated in the following way:

vik+1 = ωkvik +b1r1(pi k −xik)+b2r2(pgk −xi k)
(11)

Where ωk is a latency weight which was created to all the more likely control investigation and misuse. Reasonable determination of ωk gives a harmony among worldwide and neighborhood investigation and abuse hence quickens the algorithm convergence speed. pik is the position relating to pbest of molecule I at the kth emphasis, and pgk speaks to the situation of gbest at the kth cycle. r1, r2 are irregular numbers between 0 and 1. b1 and b2 are the speeding up constants that draw every molecule to pbest as well as gbest locations and be able to be set as b1 =b2 =2. The reason for figuring vik+1 as in (11) is to keep up partition of particles in the gathering also to look through a more noteworthy space.

Coming up next is the procedure on behalf of actualizing the PSO calculation in detail, the cycle will discontinue when a rule is met, typically a greatest number of emphases or an adequately decent fitness. Here, we utilize a fixed number of swarm iterations as the halting criteria.

Initialize

Step 1 : Set constants b1,b2, ωk, the maximum velocity vmax and maximum iterations kmax, set counters k =0.

Step 2 : Initialize a population of particles with random positions xi0 ∈ D for i = 1,•••,p and velocities 0 ≤ vi 0 ≤ vmax for i=1,••• ,p.

N=Step 3 : Estimate fitness values f i0 using initialized positions xi 0 for i=1,••• ,p

Step 4 : Set f ibest =f i0,pi0 =xi0 for i=1,••• ,p.

Step 5 : Set f gbest to best f ibest and pg0 to corresponding xi0.

1. Optimize

Step 1 : Update particle velocity vector vik+1 by Equation (11) and if vik+1>vmax
then set vik+1 = vmax, for i =1 ,••• ,p.

Step 2 : Update particle position xik+1 rendering to Equation(10)for i=1,••• ,p.

Step 3 : Estimate fitness value f ik+1 using xik+1, for i=1,••• ,p.

Step 4 : If f ik+1 is enhanced than f ibest then f ibest=f ik+1,pik+1 =xik+1 else pik+1 =pik, for i=1,••• ,p

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Step 5 : If f ik+1 is improved than f gbest then f gbest=f ik+1,pgk+1 =xik+1else pgk+1 =pgk, for i=1,••• ,p

Step 6 : Set k =k +1 and loop to step 2(a) until k >kmax.

Particle's velocity going on all measurement is clasped to a greatest speed vmax which is a parameter specified by the client. In the event that the speed on one measurement would surpass vmax, at that point it will be restricted to vmax.

4. MPSO ALGORITHM

Xing Zhang, Kang Song, Chunguo Li, Luxi Yang. Presented MPSO Algorihm [27] which give every particle's position represent a potential pair of {al,τl}. The ideal Doppler scale factor and time interval can be discovered by PSO calculation. So PSO calculation can be applied in signal identification and channel parameters approximation. Be that as it may, PSO calculation can just identify the parameters of the most grounded way as all particles are looking for gbest. For MSML channel, parameters of every individual way should be identified, in this manner some modifications are vital. This paper proposes a modified PSO (MPSO) algorithm. In MPSO, we recognize two ways by the distinction estimation of time delay, for example, the distinction estimation of time interval of two ways ought to fulfill the accompanying recipe:

$|\tau i - \tau j| > \delta peak, I \neq j$ (12)

Where δpeak is the set limit. For every way, its fitness worth will be the most extreme fitness estimation of particles which are separated into a similar way. What's more, we use lbest to refresh molecule's speed rather than gbest. The procedure for actualizing the MPSO calculation is as per the following [27].

2.Initialize

Step 1 : Set constants b1,b2,ωk, the maximum velocity vmax and maximum iterations kmax, set counters k =0.

Step 2 : Initialize a population of particles with random two-dimensional positions xi 0 ∈ D for i = 1,⋯ ,p and two-dimensional velocities 0 ≤ vi 0 ≤ vmax for i =1,⋯ ,p.

Step 3 : Calculate fitness values f i0 using xi 0 for i = 1,⋯ ,p. and if f i0> T1, xi0 and corresponding f i0 will be added to a multipath list and be written as pilbest and lbest(i) respectively.

Step 4 : Set fibest =f i0,pi0 =xi 0 for i=1,⋯ ,p

1. **Optimize**

Step (i) : For each particle i, find out the adjacent τl from the multipath list. If f ik <lbest(l) then bounce to step (ii) else bounce to step (iii).

Step (ii) : Update particle velocity with the following equation:
vik+1 = ωkvi k +b1r1(pi k −xik)+b2r2(pllbest −xik) where pllbest is the position of the lbest(l), and update particle position using Equation (10).

Step (iii) : Update particle velocity with the following equation:
vik+1 = ωkvik +b1r1(pi k −xik) and update particle position using Equation (10).

Step (iv): Set i=0. Calculate fitness value fik+1 using xik+1.

Step (vi) : If f ik+1>min(lbest) then bounce to step (vii), else set i =i +1 and bounce to step (v).

Step (vii) : Find out the nearest τlfrom the multipath list and compute the difference value of time delay: τ =|τi−τl|.

Step (viii) : If δτ>δpeak then add xi k+1 and corresponding f ik+1 to the multipath list to represent another potential path and update particle best value f ibest and position pik+1, bounce to step(x),else update particle best value f ibest and position pi k+1, bounce to step (ix). If lbest(l) < f ik+1, then update lbest.

Step (x) : If i> p, then set k =k+1 and bounce to step (xi), else set i=i+1 and bounce to step (vii).

Step (xi) : Loop to step (i) until k >kmax.

Step (xii) : Select {al,τl} from the multipath list whose lbest(l) > T2, consequently, {al,τl} are the Doppler scale factor and the time delay of path l respectively.

Note: δpeak, T1 and T2 are three edges we have to set for this calculation. δpeak is set as the base contrast of time defer that can recognize two ways. T 1 is the standardized limit for the introducing of the multipath rundown and its worth can be a little positive number, generally 0.1 or 0.2. T2 multipath list. It is set by the ideal signal to noise ratio (SNR) is the standardized vitality limit used to choose parameters.

2. HSA-MPSO Algorithm for Finding the Shortest Path

The hybrid HSA-MPSO algorithm is structured dependent on normal qualities of HSA and MPSO calculation. The new arrangements are delivered by HSA dependent on the Harmony Memory Considering the Rate (HMCR) and Pitch Adjusting Rate (PAR) parameters. It improves the expectation of worldwide ideal incentive by enabling the answer for move out from nearby optima. This is the motivation behind why MPSO is converged with HSA to conquer the high dimensional issues during the procedure of investigation and misuse. The MPSO enables the swarm particles to move between the areas and updates the speed and position after every cycle. The high search productivity of MPSO enables the hunt to be performed in more than one area utilizing HSA. Subsequently, in this paper, the authors use HSA-MPSO Algorithm for Finding the Shortest Path in every vertices pair (s,t) over a graph G. The HSA-MPSO Algorithm is appeared in Figure 2.

Fitness Function

The multi-objective fitness functions of the proposed HAS-MPSO algorithm to find the shortest path i.e. minimum path value from the source to sink node. Hence, the multi-objective fitness function is defined as follows:

$$f = \frac{1}{\sum_{i=1}^{N-1} \cos(t, p+1) + E(i) + BER(i)} \quad (13)$$

Where

N – total number of nodes.

$\cos(t, p+1)$ - cost of adjacent sensor nodes.

The shortest path computation using HAS-MPSO algorithm is given as follows,

The algorithm is achieved in steps and it is separated into iterations (refer the steps below). At each iteration, the information is collected by CH from all cluster members and forwards it to the BS. The steps of HSA-MPSO are given below:

Step 1: Parameter Initialization

The initial WSN requires suitable energy in the nodes is generated based on initial parameters, refer Table 1.

Step 2: Initializing the position and velocity of particle

The velocity and position of particle is haphazardly produced inside the range [Vmin, Vmax] and [Xmin, Xmax]. Here, Particle Harmony Memory (PHM) is named because of introduction of consonant memory and swarm size. At beginning stage, arrangements are created haphazardly at the PHM to streamline the given issue. The arrangement is planned as a k listed number of CH, which is given in Eq.(14). For the given streamlining issue, the rows in PHM is viewed as the arbitrary arrangement and subsequently the fitness function is calculated for each hybrid vector.

$$\begin{bmatrix} I_1^1 & I_2^1 & \cdots & I_k^1 \\ I_1^2 & I_2^2 & \cdots & I_k^2 \\ \vdots & \vdots & \ddots & \vdots \\ I_1^{HMS} & I_2^{HMS} & \cdots & I_k^{HMS} \end{bmatrix} \quad (14)$$

Step 3: New Harmony Vector is improvised from PHM

$$\left[I_1', I_2', \ldots, I_k'\right]$$

A harmony vector is unarranged from Eq.(14), anywhere the apparatuses of the harmony vector is produced from Eq.(11).

$$I_j^{'} \leftarrow \begin{cases} I_j^{'} \in PHM \ \text{with } p(HMCR) \\ I_j^{'} \in I_j \text{with } p(1-HMCR) \end{cases} \quad (15)$$

where,

HMCR – Component selection probability from PHM, and

(1-HMCR) – Random component selection probability.

When the random component selection probability is generated through PHM, it is altered further as per PAR. It standardizes the candidate selection possibility from PHM for mutation and (1-PAR) is the probability of doing in other sense. The PAR selected during the candidate selection probability is given by,

$$I_j^{'} \leftarrow \begin{cases} I_j^{n} \in PHM \ \text{with } p(\text{PAR}) \\ I_j^{'} \ \text{with } p(1-PAR) \end{cases} \quad (16)$$

where - nearest node with higher energy than the present CH.

Step 4: Update harmony matrix

The fitness function is used to calculate the produced hybrid harmony vector at each row (pbest). When the fitness value of New Harmony vector is greater than worst harmony vector, then the new vector is updated in PHM and poorest vector is detached.

Step 5: Updating particle position and velocity

The optimum position of CH is determined by finding the finest swarm particle with less cost function over n iterations. The particle finest position and global best position is determined over each iteration, which is given by pbest and gbest. The nodes are organizing with the gbest nodes are designated as CH. Further, the velocity of each node is modernized after each iteration and the update is completed based on the information like present velocity, present position (pbest) and distance between pbest besides gbest. It is formulated as,

(17)

Where,

Vij(r) – particle velocity at r,

Xij(r) – particle position at r,

i – ith particle,

j – dimension

r1 and r2 – uniform random values between [0,1],

w(r) – inertia weight factor or linearly decreasing factor

c1 and c2 – acceleration constants,

pbest – particle's local position and gbest – global best position.

The use of linearly decreasing factor w progresses the performance, where the value is linearly decreasing between 0.9 and 0.4 during each iteration. Inertia weight is selected appropriately and it affords apt poise between the local and global consideration and utilization. This produces optimal solution in fewer iteration and the value of which is given by,

$$w(t) = w_u + (w_l - w_u)\left(\frac{t}{T_{\max}}\right) \quad (18)$$

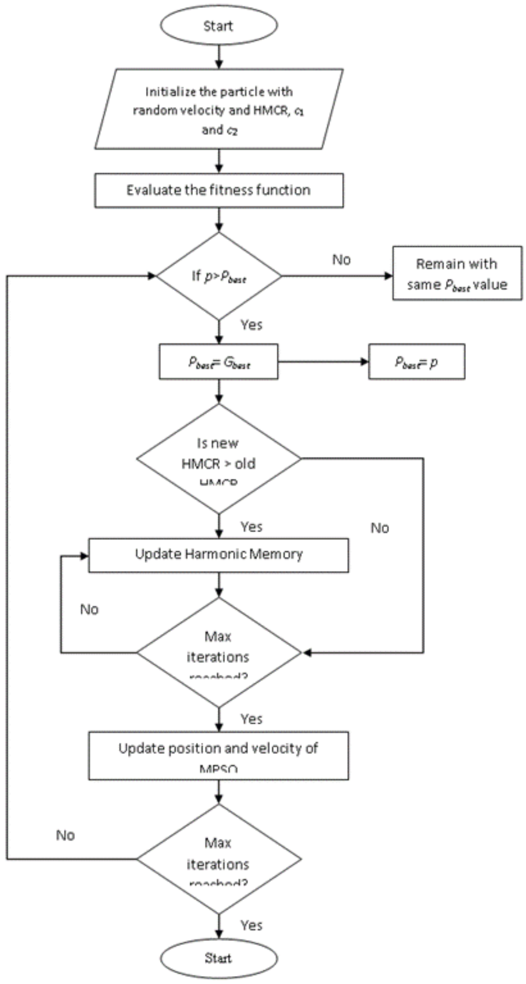

Figure 2. Flowchart of HAS-MPSO Algorithm

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where, wu = 0.9, wl = 0.4, Tmax – total iterations and t – current iteration.

The particle best or pbest is selected based on the nodes with less cost. Likewise, gbest is also selected in the similar manner. The nodes are lying near to the range of gbest is taken as CH and finally, the velocity and position of such node is modernized the completion of each iteration.

Step 6: Termination is reached

Once the complete procedure reaches the maximum iterations, end the algorithm, then repeat the procedure till optimal solution is found.

The shortest path is got if the multi-objective fitness function touches the maximum value. The other paths with minimum fitness value is considered as penalty value and hence no shortest path is made. Further, closeness centrality considers the shortest path distance set up between the two nodes, which is given by,

$$C(v) = \left[\frac{\sum_{i=1}^{N} d(a,b)}{n-1} \right] \quad (19)$$

$\sum_{i=1}^{N} d(a,b)$

Where, is the summation of converse shortest distances between two points and n-1 is the entire number of nodes in the graph

III. NETWORK MODEL

The system model expected in the present investigation utilizes a smart grid with 500kV power grid station, which is the local power distribution area (LPDA). The essential information the executives focus and base station assumes a significant job in controlling the substations and the board of local power. The power dispersion arrange has 1000 transmission networks are utilized for assessing the viability of the proposed technique. The separation of transmission between the individual matrices is thought to be 20m in LPDA. In such condition, the nearness of haphazardly circulated remote correspondence between the nodes in transmission territory makes extra difficulties to convey versatile, dependable and practical arrangement with exactness and quality utilizing convenient issue finders.

6.1 Path loss Model

In the present investigation, a log-ordinary shadowing path-loss model is utilized and the parameters of which is given in Table 2.This path-loss model exhibits more exact direct estimation in multipath condition than Rayleigh or Nakagami models in smart grids. The log-typical shadowing path-loss model is expressed in mathematical form, which is given below:

$$\gamma(d)_{dB} = P_t - PL(d_0) - 10\eta \log_{10} \frac{d}{d_0} - X_\sigma - P_\eta \quad (20)$$

where, the parameters are given in Table.2.

IV. RESULTS AND DISCUSSIONS

The SPOCC with HSA-MPSO algorithm is executed in Matlab 14 on a 2.13 GHz processor with 8 GB memory. The parameters for simulation are exposed in Table.2. For simulation purpose, the BS is reflected at the center of the network. The presentation of the proposed routing method is verified against: Fish Bone Routing Algorithm [14], Bird Mating optimization Algorithm [3] and Multi-path QoS-aware routing [16] algorithm. The performance metrics like average end to end delay, packet delivery ratio, mean throughput and average residual energy.

Table.2. Global Simulation Results

Parameter	Value
Routing Parameters	
Size of the Topology	1000 × 1000 m2
Total number of nodes	1000
εmp	0.0013 p/bit/m4
εfs	10 pJ/bit/m2
Eelec	50 nJ/bit
α	2
Probability of Cluster Head	0.1
Number of cluster Heads	5
Packet size of data	4096 bits
Routing Algorithm	SPOCC-HAS-MPSO
Aggregation of data	0.6
Probability of heterogeneity	0.1
Initial Energy	0.5 J
Swarm size	15

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HMCR	0.95
PAR	0.8
[Xmin, Xmax]	[0,200]
[Vmin, Vmax]	[0,200]
c1 or c2	0.25 or 0.5
Distance between the nodes	Randomly distributed [1]
Topology	Random [1]
Encoding	Manchester [1]
Smart Grid Environment with Substation Load	500 kV [1]
Average packets sent per second	12 Pkt/s [1]
Cognitive scale parameter (b1)	2
Social scale parameter (b2)	2
Inertia weight (ω_K)	1
Two- dimensional maximum Velocity (V_{max})	1,02,512 samples
Maximum iterations (K_{max})	30
Population of particles (p)	200
Threshold 1 (TI)	0.1
Threshold 2 (T2)	0.4
Delay difference threshold (δpeak)	30 samples
Path Loss Component	
Grid Station (outdoor)	500 kV
Noise power	Pη dBm
Transmit power	PtdBm
Path-loss exponent	η
Shadowing deviation (σ) for Line of sight	3.12
Shadowing deviation (σ) for Non-line of sight	2.95
Signal to noise ratio	γ(d)
Path loss exponent (n) for Line of sight	2.4
Path loss exponent (n) for Non-line of sight	2.4
Zero mean Gaussian random variable with standard deviation	Xσ
Noise floor for Line of sight	−88
Noise floor for Non-line of sight	−93
Path loss at reference distance	PL(d0)

From the Figure 3, it is seen that the average end-to-end delay of the SPOCC-HSA-MPSO method is lesser than the other three methods. As the node density increases, the delay slightly increases, however, it is very minimal than the other methods. Since, this method avoids centrality within its range, the delay is minimal and the hybrid optimization algorithm provides fastest routing process.

Similarly, the packet delivery ratio, shown in Figure 4 proves that the SPOCC-HSA-MPSO is efficient than the conventional methods. The results shows that the PDR of SPOCC-HSA-MPSO is higher than the other methods. This helps to maintain the integrity of data transmitted avoids centrality problem associated with the network.

The Figure 5 shows the Mean Throughput between the SPOCC-HSA-MPSO is efficient than the conventional methods. It is seen that the SPOCC-HSA-MPSO has higher throughput range than the existing methods. This is due to optimal finding of gbest position by hybrid algorithm at a faster convergence rate. The convergence rate is obtained with greater initial step and greater □values.

Further, SPOCC algorithm supports the network with high average residual energy than the other methods (Figure 6). It is seen from the results that the SPOCC-HSA-MPSO has higher Average Residual Energy. It is due to the fact that the hybrid algorithm converges at a faster rate than the other algorithms and SPOCC enables faster routing process.

The Figure 7(a) shows the total number of dead nodes with least dead nodes reported by the proposed method. On contrary, the number of alive nodes is maximum in proposed method, which is evident from Figure 7(b) and 7(g). The increased lifetime of proposed system sends large number of packets to the base station (refer Figure 7(c) and 7(d)). The increased lifetime of nodes helps to increase the average energy level of nodes, which is shown in Figure 7(e) and Figure 7(f).

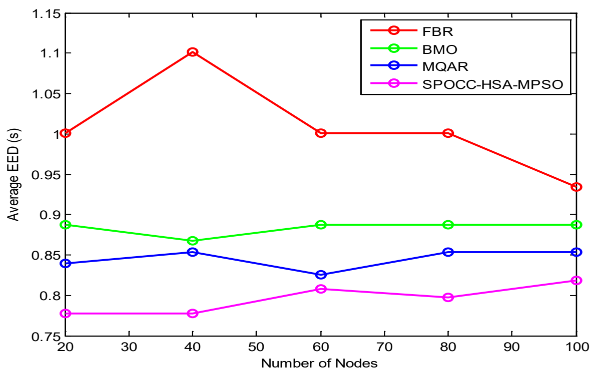

Figure 3: Average end-to-end delay

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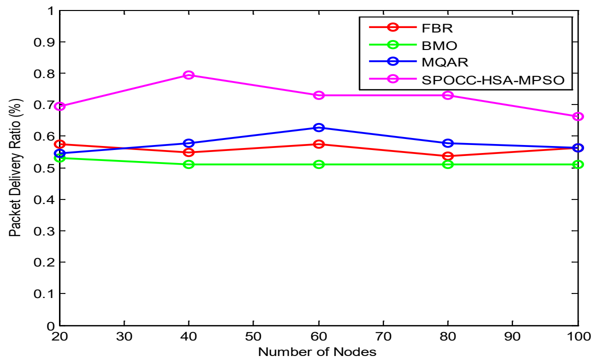

Figure 4: Packet Delivery Ratio

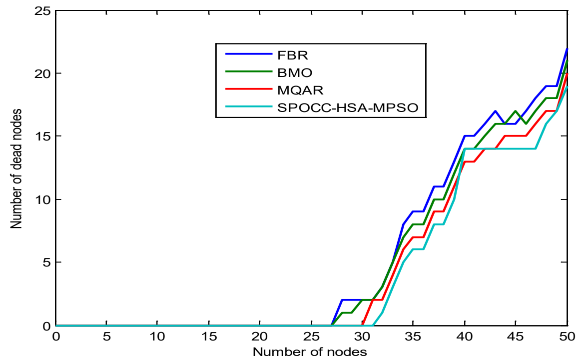

Figure 7(a) Number of dead nodes

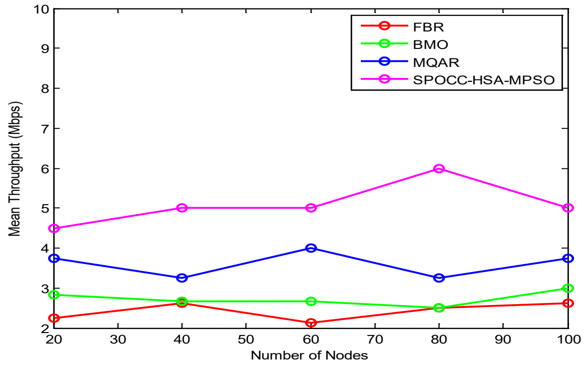

Figure 5: Mean Throughput

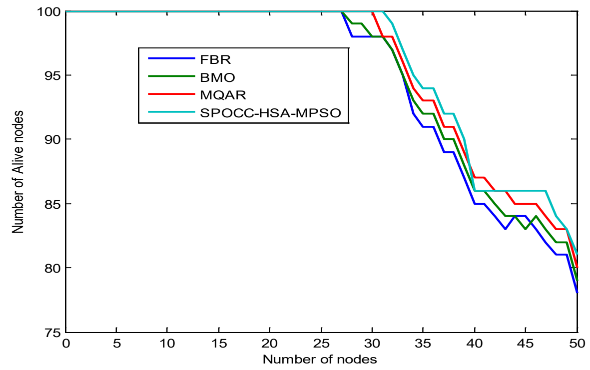

Figure 7(b) Number of alive nodes

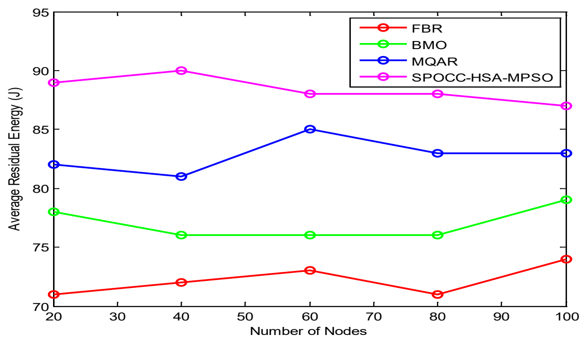

Figure 6: Average Residual Energy

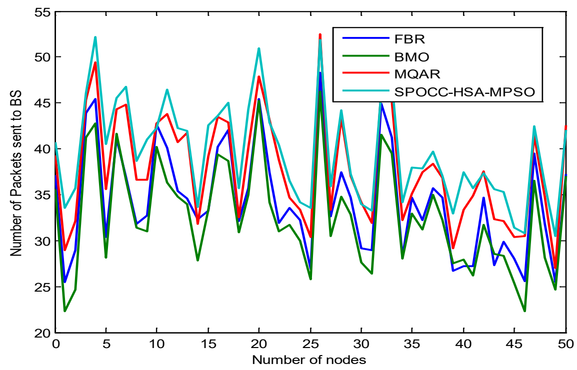

Figure 7(c) Number of packets sent to Base station

From the results, it is seen that the SPOCC based hybrid algorithm attains a better performance rate than the existing algorithm. Average increase in residual energy of proposed system has increased to 14%, 21% and 23% than Multi-path QoS-aware routing algorithm, Bird Mating optimization Algorithm and Fish Bone Routing Algorithm. The algorithm proves to be efficient and handles the consumption of energy in an efficient way.

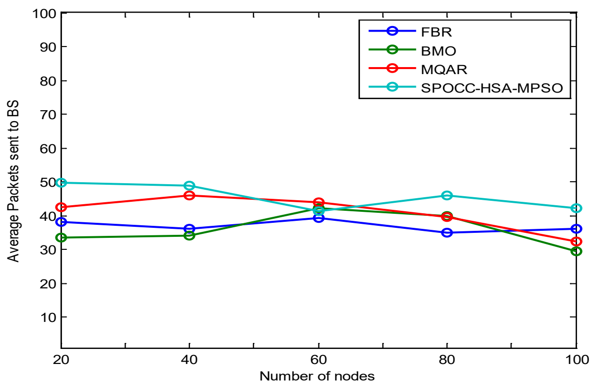

Figure 7(d) Average Number of packets sent to Base station

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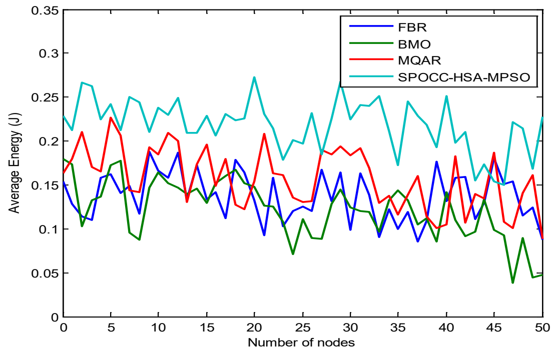

Figure 7(e) Average energy level of nodes

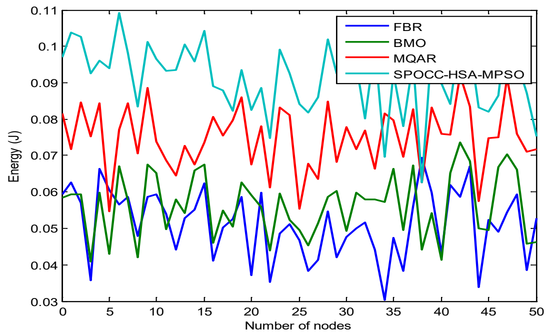

Figure 7(f) Energy level of nodes during simulation

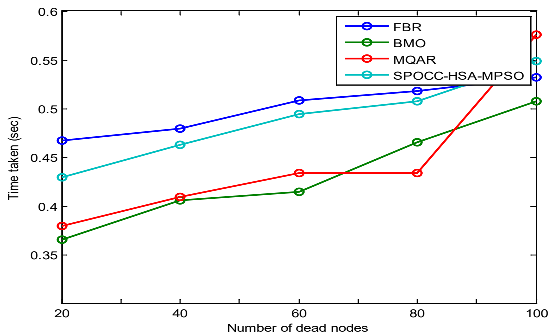

Figure 7(g) Time taken for death of nodes in the network

CONCLUSIONS

In the Proposed system, proliferations of WSNs in smart grids establish Industry 4.0. The significant factors are the combinations of apparatus to implement reconfigurable and supple classification to raise the efficiency of manufactures. The smart grids clinched the innovation in WSN through provided that effective monitoring as well as casing the intact geographical region at lesser costs. On the other hand, the smart grids infrastructure is measured untrustworthy and ineffective in terms of WSN communication; for this reason a communication structure is mandatory to develop the network consistency. In the paper, the authors executed routing among the smart grids with SPOCC-HSA-MPSO technique through the actual behavior of HSA and MPSO individuals. The SPOCC works with an operator calculus, which sustains the coverage, connectivity and power of the nodes in smart grid environments. Utilization of hybrid HSA-MPSO algorithm helps to improve the average residual power of the node with its shortest path calculation at faster convergence rate. The energy dissipation is decreased in addition that the network life span is enhanced by SPOCC. In the simulation results, it is observed that the sensor network with hybrid harmonic search and operator calculus raises the network throughput by 32%, 30% and 50% than Multi-path QoS-aware routing algorithm, Bird Mating optimization Algorithm and Fish Bone Routing Algorithm. In brief, the SPOCC is authenticated next to individual WSN designs and it is found that proposed system is privileged in smart grid applications. In future, parameters like load balancing, barriers, consistency and steadiness of the network could be considered in the account.

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