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Swarm Intelligent Cluster Head Selection Techniques in WSNs

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Abstract:
Wireless Sensor Network (WSN) is established with many sensor nodesto sense information from surrounding area. WSNs sensor nodes are battery operated devices. Therefore, energy efficiency is critical issue in WSNs. There are many energy efficient algorithms have proposed to improve the network lifetime. This paper performs comparative analysis of various swarm intelligentalgorithms like Energy-efficient cluster head selection using improved Sparrow search algorithm using Differential evolution (EECHS-ISSADE), Hybrid Partial Swarm Optimization and Tabu Search (Tabu-PSO), Energy-efficient CHS using ABC (EECHS-ABC)and Low Energy Adaptive Clustering Hierarchy (LEACH) classical algorithmon the basis of alive nodes, residual energy and throughput.
Keywords:EECHS-ISSADE, TABU-PSO, EECHS-ABC, and LEACH.

1. Introduction

Wireless Sensor Networks have been considered wireless network that are consisting of different sensor nodes and Base Station. These nodes and base stations monitor various circumstances. These circumstances are motion, temperature etc. because of limited source of battery. This battery could not be changed due to inaccessibility of location of Wireless Sensor Network by human. Energy efficient protocols are performing with the support of chain based and clustering based protocols [1].

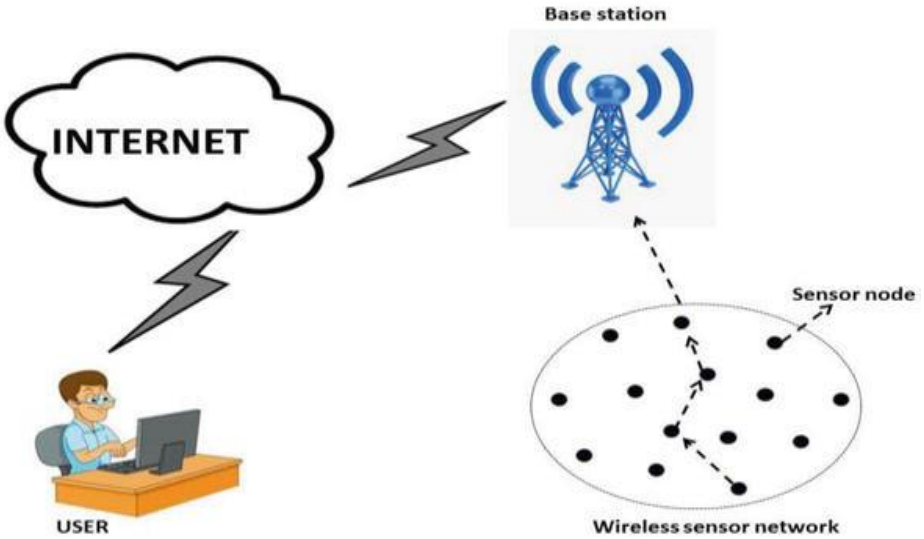

Figure 1 Wireless Sensor Networks

It has been observed that chain based protocols are increasing delay in case of dense network. These values are shared in the company of sink node. These values are transmitted by means of node to node transmission and group heads. Information's are transmitted in the direction of group head nodes by sensor node. This information is further forwarded to BS for further communication. Overall picture of Wireless Sensor Networks is illustrated in figure one. It has been clearly noticed from this figure that sensing device, group heads (CH) and another intelligent mechanics transmitted information in the direction of sink node or information server. WSNs security is play important role to deliver secure transmission from sensor nodes to sink node [2-3]**.**Therefore, low energy in nodes is major challenge in WNSs. The Quality of Service (QoS) used to improve energy efficiency [4] many clustering algorithms have been proposed in the literature.

The clustering is collection of multiple clusters with cluster members.Other sections are structures as: section 2 represents literature reviews which have been performed in this area. The experimental setup and results comparisons are discussed in section 3. In last section 4 represents the conclusion and future work.

2. Literature Review

In last few year many classical and meta-heuristics techniques has introduced to select optimal cluster head.These techniques play important roles to improve energy efficiency in WSNs. The main objective is to proposed clustering protocols to select the cluster head and discover parameters. Low Energy Adaptive Clustering Hierarchy (LEACH) [7]is probabilistic and hierarchical protocol. It works based on topology monitoring feature. It selects cluster head randomly and energy is spreading between the nodes. The coordinate clustering performedenergy utilization and network lifetime. The random cluster head selection optimized the energy utilization.Self-organize clustering used to improve the network lifetime. It performed cluster head selection based on the residual energy.But in some cases CH has elected bases on low residual energy that effect on network lifetime [22].Many existing classical and meta-heuristics algorithms have been proposed to improve the energy efficiency of wireless sensor network [3].Energy-efficient CHS using Artificial Bee Colony (EECHS-ABC) algorithm has proposed to select cluster headbasis on residual energy, intra-cluster distance, and distance from base station [1].It minimized the energy consumption and improves the network lifetime. The simulation results performed better performance as compare to existing algorithms.An energy-efficient dynamic Cluster Head Selection with Particle Swarm Optimization algorithm (EEDCHS-PSO) has introduced to select optimal cluster head selection. It selects best cluster head and performs energy utilization during cluster formulation and cluster head selection [6]. The cluster head performs data transmission form inter-cluster to cluster head and cluster head to base station. The performance analysis performs better results in energy utilization, overhead and load balancing.Breeding Artificial Fish Swarm Algorithm (BAFSA) [16] has proposed to optimize energy efficiency. The optimal cluster heads performs on the basis of intra cluster distance and residual energy parameter to decrease energy consumption and extend network lifetime.A hybrid Grasshopper Optimization Algorithm (GOA) and Crow Search Algorithm (CSA) based optimal CH Selection (HGWCSOA-OCHS) [19] has proposed to extend the WSNs lifetime. It reduces delay and resolves the convergence issue. It utilizes search space effectively.The experimental results have more alive nodes, less dead nodes and reduce energy consumption in WSNs.Firefly algorithm (FA) with cyclic randomization algorithm (FCR) [14] performed cluster head selection and improve energy level. It has large possible alive nodes.

Hybrid Artificial Neural Network has implemented to improve the lifetime of WSNs. It is integration of artificial neural network and LEACH [8]. It optimizes energy during selection of selection of cluster head. It uses short distance, less computation cost to select cluster head.A hybrid dragon fly algorithm has proposed to select optimal cluster head selection. It is hybridization of Dragon-fly and FA algorithms. It performs the cluster head selection on the basis of distance, energy and delay [2]. The Firefly location is changed with Dragon-fly. The performance comparison of FPU-DFA has given better results in terms of network energy, delay and alive nodes. A novel genetic algorithm based optimized clustering (GAOC) has introduced to optimize network lifetime. The cluster head selection performs on the basis of distance to the base station, high residual energy and node density [20]. A hybrid FA has proposed to improve the global search and perform balancing between exploration and exploitation search space. It uses variation of FA, PSO and LEACH-C to select the optimal cluster head selection [10]. The simulation results have proved the effectiveness on the basis on alive nodes, network life time and more residual energy. The hybrid cluster head algorithm has proposed to extend lifetime of WSNs.It is hybridization of PSO AND ECHS algorithms. The performance analysis has performed in the term of intra-cluster distance; residual energy and BS distance [12]. Further, a hybrid PSO algorithm has proposed to elect optimal cluster head. It is integration of HAS-PSO algorithm.HAS algorithm has search ability and pso algorithm has cluster head selection capability. The performance of HAS-PSO gave better results on the basis of number of alive

nodes, dead nodes, residual energy and throughput [17]. A hybrid tabu search with PSO (TS-PSO) introduced to optimize network energy. It extends network lifetime and balances energy wastage. It also performs search in global optima [21]. The novel cluster head approach proposed to cluster head section. Cat Swarm Optimization (CSO) uses intra cluster and residual energy to optimize energy efficiency in WSNs. The simulation results have proved that CSO gave better results as compare to other existing techniques in term of network lifetime, overhead, energy consumption and throughput.Hybrid Artificial Bee Colony and Monarchy Butterfly Optimization Algorithm (HABC-MBOA) has proposed to optimize energy level in WSNs [11]. It is hybridization of ABC and MBOA. It performs search in global search space.

3. Experimental setup

The comparattive analysis has implemented to evalute the performance of EECHS-ISSADE [26], TABU-PSO[21], EECHS-ABC [1], and LEACH [7]on the basis of alive nodes, residual energy and throughput.The performance analysis of the different algorithms has been performedin MATLAB R2018B with 8 GB RAM, Window 8 and Intel core i3 CPU.

Table 1: Simulation setup in WSNs

Simulation parameters.

Parameters	Value
Sensor field area	200x200 m^2
Number of nodes(n)	100
Percentage of cluster head	5–10%
Radio propagation model	Free space
Min and Max Position of BS	[0,200]
Antenna model	Omni directional antenna
Initial energy (E_0)	0.5 J
Electronics energy (E_{elec})	70 nJ/bit
Energy for free space (E_{fs})	10 pJ/bit/m^2
Energy for multipath (E_{mp})	0.0013 pJ/bit/m^4
Packet size	4096 bits
Energy data aggregation (E_{DA})	5 nJ/bit/signal
MAC	802.11
Number of rounds (I_{max})	2000
Scaling Factor(ε)	0.5
Crossover Probability Rate	0.5

Table-2Analysis of Alive Nodes

ROUNDS	EECHS-ISSADE	TABU-PSO	EECHS-ABC	LEACH
0	99	97	95	94.5
200	99	96	94	93
400	98	88	85	80
600	80	70	56	45
800	75	55	40	26
1000	50	34	28	18
1200	32	23	12	10
1400	24	14	8	7
1600	15	4	4	6
1800	7	3	2	1
2000	0	0	0	0

The table-1 describes the simulation setup with different parameters values.The figure-2 and table-2 present the alive nodes analysis in WSNs. The number of alive nodes analysis with number of rounds. The proposed EECHS-ISSADE has high number of alive nodes on different rounds as compare to TABU-PSO, EECHS-ABC, and LEACH. Therefore, the proposed algorithm has proved effectiveness and performs energy utilization.

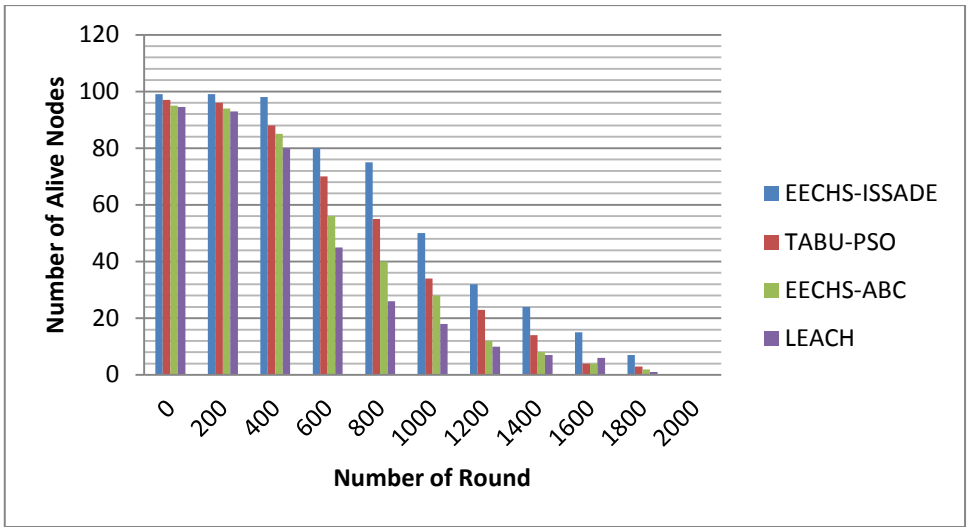

Figure-2Percentage of alive nodes

Table-3 Average throughput of sensor nodes

Sensor Nodes	EECHS-ISSADE	TABU-PSO	EECHS-ABC	LEACH
100	8	5	4	3
200	10	9	8	7
300	13	10	9	8
400	19	13	10	9
500	20	14	13	10
600	30	19	16	11
700	31	22	17	12
800	39	26	19	17
900	47	30	21	18
1000	55	35	26	22

The table-3 and figure-3present the average throughputin WSNs. The total number of packets received to the time taken by receiver to transfer last packets, called throughputs. The EECHS-ISSADE gives better average throughputs in each roundas compare toTABU-PSO, EECHS-ABC, and LEACH. Therefore, the proposed algorithm has proved effectiveness and performs energy utilization.

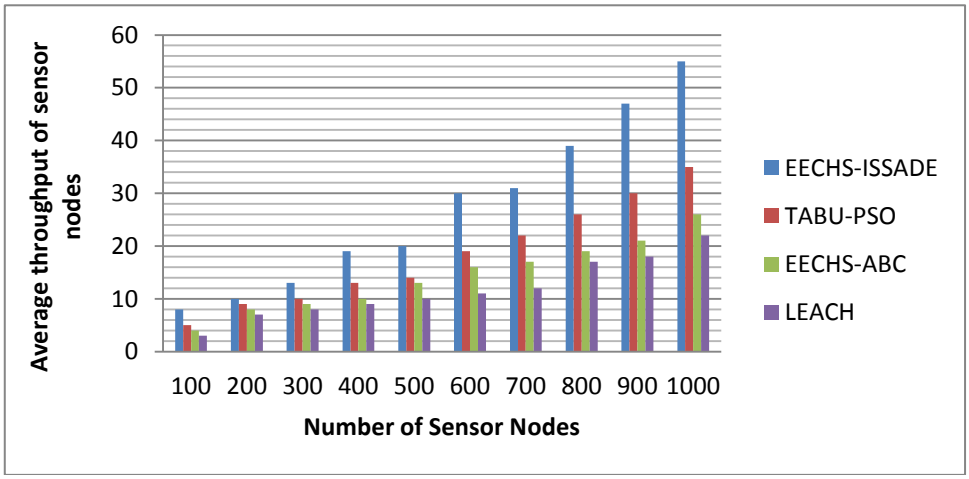

Figure-3Average throughput of sensor nodes

Table-4Percentage increase in mean available residual energy of sensor nodes

Sensor Nodes	EECHS-ISSADE	TABU-PSO	EECHS-ABC	LEACH
100	21	16	12	11
200	20	14	11	10
300	19	13	10	09
400	16	12	09	08
500	14	11	08	07
600	13	09	07	06
700	11	08	06	04
800	10	07	05	03
900	09	06	04	02
1000	07	05	03	01

The table-4 and figure-4represents percentage increase in mean available residual energy of sensor nodes. The residual energy is remaining energy of sensor nodes after completion of round. The EECHS-ISSADE gives residual energy in each round as compare to TABU-PSO, EECHS-ABC, and LEACH. Therefore, the EECHS-ISSADE has proved effectiveness and performs energy utilization.

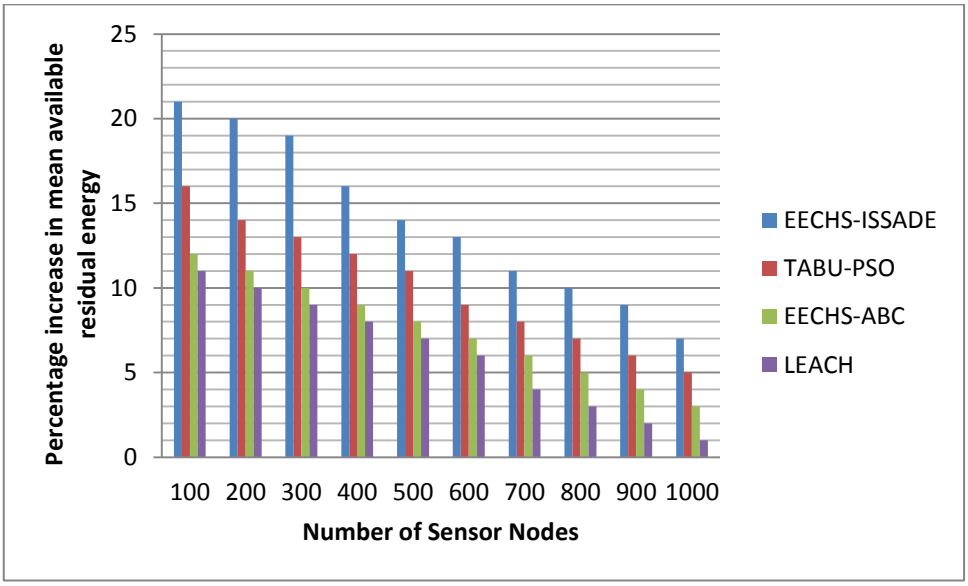

Figure-4Percentage increase in mean available residual energy of sensor nodes

4. Conclusion

Energy utilization plays a key role in wireless sensor networks. In the view of energy utilization, many algorithms have been applied before. But there have been some shortcoming like week convergence, improper balancing, high energy consumption and high delay.This paper hasperformed comparative analysis of EECHS-ISSADE, TABU-PSO, EECHS-ABC, and LEACHon the basis of alive nodes, residual energy and throughput. The EECHS-ISSADE has given better results as compare to existing protocols. This paper only focuses on cluster head selection. In future work we can implement these algorithms for node deployments and optimal route selection.

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