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PSOEEC : Optimization of Energy Efficient Clustering by Particle Swarm Optimization(PSO) for Internet of Things(IoT) Applications

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ABSTRACT

Clustering is an wireless network approach formed with sensing nodes are placed in an area for monitoring the physical objects to perform applications of temperature, health care, environment monitoring and agriculture. The sensor nodes are equipped with less energy with re-chargeable battery support for that life of sensors are limited period for that its challenging task to perform communication, operations with other nodes in a network. It is essential to implement an algorithm for enhance better efficiency of sensor nodes for energy conservation. In this paper optimization of clustering, cluster head selection implement by Particle Swarm Optimization(PSO) based Energy Efficient Clustering (PSOEEC) algorithm for better clustering approach in Internet of Things applications. This algorithm will improves power consumption and network lifetime.

Keywords – Clustering, Cluster Head, Internet of Things, Particle Swarm Optimization, Sensor node, Network lifetime.

I. INTRODUCTION

Internet of Things(IoT) is a part for uprising of Internet. IoT communicate with objects, sensing devices are linked with one another for providing smartness. In IoT, the physical objects are sensed, object's motion is monitoring, controlling by sensor devices. IoT technology brings these physical devices into digital system where provide improvement for reliable, perfection and smartness.

The various applications perform by Internet of Things as environmental tracking, whether forecasting, tracking & monitoring objects etc. The sensor nodes are take important things to perform in IoT applications. These nodes performing of motion monitoring of objects, data gather from other objects and accessed data send to the base station for final processing final results. While participating these steps of sensor nodes are in nature they are having less energy and battery chargeable and within short period they consuming energy and every time sensor nodes are chargeable. For that reason consumption of energy a demanding task of sensor nodes. Clustering approach for these

Internet of Things scenario is to reduce consumption of energy, enhance lifetime of network. In clustering, nodes do communication for send & receive data with neighbor nodes ultimately send this collected data to base station. All these sensor nodes collects the data and send to cluster head. The cluster head send this received data to base station. The cluster head selection in clustering is a an important task to save energy of all sensor nodes in a cluster. To optimization of these clustering and cluster head selection based on nature inspired computing methods are introduced.[1-4]. LEACH is a clustering algorithm, in that selection of cluster head based on probability of sensor node for protect energy. For selection of cluster head not consider the remaining energy. In LEACH select cluster head die within short time because while selection of cluster head with a low energy. It is not affordable[1]. In[5] proposed centralized LEACH while selection cluster head, the distance between nodes, energy of each node considered. In[6], proposed Particle Swarm Optimization (PSO) is nature inspired computing algorithm in that consider total initial energy ratio of nodes and residual energy of all nodes but not calculate the distance between cluster head and base station. In[7] while cluster head selection remaining energy of sensor node, density of node is calculate but formation of cluster not calculated which have more consumption of energy. In[8] proposed cluster head selection model by LEACH protocol by three phase of data transmission from sensor node to base station by calculating energy consumption. In[9] Proposed a real-time IoT concept and to distributing power consumption to equal to all sensor nodes depend upon total no. of messages send by one second time. As per this proposed concept, decreasing replace of battery, less cost and enhance lifetime of network.

The authors contribution towards this research paper as like this…

1. Cluster formation –

2. Cluster head selection –

This research papers organize as like. Section2, introduce the network model. In Section3, the introduction of Particle Swarm Optimization(PSO). Section4, formation of clustering by using Particle Swarm Optimization(PSO) given in detail. Section5, formation of cluster head selection by using Particle Swarm Optimization(PSO)given in detail. Section6, Performance evolution and results by proposed algorithm given in detail. In Section7, Conclusion follows by References.

A. Network Energy Model

In Fig Clustering approach of Internet of Things(IoT) applications of real-time concept, the sensor nodes are deploy in target area for monitor temperature application. These sensor nodes are for sensing and gather information from objects and send these data to base station.

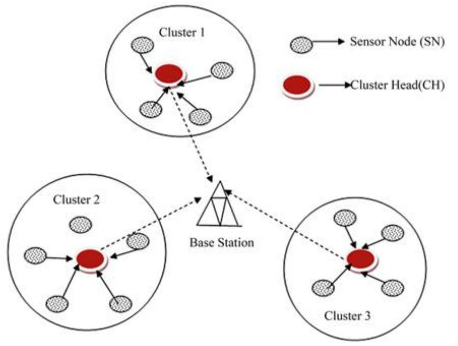

Fig 1 – Sensor nodes in clustering approach for communicating with Base station.

The sensor nodes possessed with low energy in nature, energy constrained. The power source of sensor nodes is battery. The sensor nodes must utilize wisely for minimize energy consumption and maximize network life time.

The following suppositions are important for considering deployment of nodes[10]

- ✓ After deployment the nodes will be static
- ✓ The sensor nodes are sending temperature monitoring in the environment. The Base station is collect the data from all sensing nodes.
- ✓ Sensor nodes having initial energy and identify by ID.
- ✓ By remotely the sensor nodes can use power transmission.
- ✓ For analyze the data, base station send a packetized message to cluster head for sample data from sensor nodes.

Energy model is calculate for energy loss while every sensor node communicate with other nodes in a cluster. For one-hop count free space (d^2 power loss) channel propagation model is used. For multi-path transmission (d^4 power loss) used for packetized information transmit in a wireless-network. To communicate this transmission the energy consumed l-bit packet for distance d is calculations as follows.

$$\begin{cases} lE_{elec} + l\varepsilon_{fs}d^2, & d < d_0, \end{cases}$$

$E_{TX}(l,d) =$ (1)

$$lE_{elec} + l\varepsilon_{mp}d^4, \quad d < d_0,$$

where ε_{fs} = free space energy loss

ε_{mp} = multipath energy loss

d = source node to destination node distance

d_0 = crossover distance

$$d_0 = \sqrt{\frac{\varepsilon_{fs}}{\varepsilon_{mp}}} \quad (2)$$

for spending energy from radio to receiver is $E_{RX}(l) = lE_{ele}$ (3)

In Physical & Media Access Layer(MAC) transmission power as well as receiving power energy are designed.

II. PROPOSED WORK

Particle Swarm Optimization(PSO) proposed by James Kennedy (a social psychologist) and Russell Eberhart (electrical engineer) in 1995 inspired by social behavior of bird flocking or fish schooling.

A population based approach for minimizing the functions. A maximization function is converted into minimization function as max f(z) = -min f(x). Each particle treated as a point in a N dimensional space which adjusts its "flying" according to its own flying experiences as well as the flying experience of other particles.

Each particle tries to modify its position by using the following information

- ✓ the current positions
- ✓ the current velocities-the distance between the current position and pbest
- ✓ the distance between the current position and the gbest.

BBO has certain similarities with existing well known bio-inspired algorithms are Genetic Algorithm(GA) and Particle Swarm Optimization(PSO). In Genetic Algorithm(GA), whether the parent is not fittest(not a capable), according to this, its child couldn't survive for upcoming next generation because having low-probability, but whereas in Particle Swarm Optimization(PSO) and Biogeography Based Optimization(BBO) solutions are capable to surviving for upcoming generations. In PSO, solutions are form in to same groups, whereas in BBO and GA, the solutions not into group in the cluster. The Solution of PSO is updated by velocity, whereas BBO solution is updated by directly. So BBO has provide most performance results than GA and PSO for that results[13]. The authors optimize BBO for secure cluster selection in WSN. Biogeography Based Optimization(BBO) is a nature inspired computing algorithm for designed to solve complex and real world problems for solve cluster head selection in IoT related problems. In proposed work, Biogeography Based Optimization(BBO) apply for energy efficient secure cluster head selection in the area of heterogeneous networks.

In this paper, we use the modified Bio-geographic based optimization algorithm to attain the novel approach for CH election in heterogeneous network[14]. BBO algorithm is idea of implementation by two methods i.e. immigration and emigration of species as per their habitats. In proposed work, improve the migration phase of BBO and then applied that modified BBO to WSN. The experimental results show that it performs better among others in terms of cluster head selection, lifespan, stability, energy consumption, quality of network and throughput etc. In this proposed research objective, for efficient and energetic cluster head selection approach in the area of heterogeneous network, apply nature inspired computing algorithm i.e. Bio-geographic based optimization algorithm(BBO). The main idea of implementing of this BBO is immigration and emigration of species according to their habitats. Research proposed work, modified and improve migration strategy for better cluster head selection in IoT approach. According to this proposed approach it seems that there seems improvement in efficient cluster head selection, improve life span of network, minimize energy consumption, maximize throughput and in all aspects improve the quality of service(QoS).

The research paper is organized as follows. In Section 2, includes the literature review In Section 3, describes about existing work. In Section 4, described about Biogeography Based Optimization. In Section 5, describes about proposed work. In section 6, describes about simulation results and discussion. In Section 7, includes the conclusion of this research paper

$V^i_{k+1} = V^i_k + c1.r1.(P^i_k - X^i_k) + c2.r2.(P^g_k - X^i_k)$

V^i_{k+1} = current position(velocity)

V^i_k = previous velocity

$c1.r1.(P^i_k - X^i_k)$ = personnel influence

$c2.r2.(P^i_k - X^i_k)$ = social influence

P^i_k = is particle best (local)position

X^i_k = is particle initial position

P^g_k = is particle global position

c1 = is the acceleration factor related to pbest

c2 = is the acceleration factor related to gbest

r1,r2 = are two random number between 0 and 1.

One of the best population based optimization is Particle Swarm Optimization (PSO). The particles are possible solutions in PSO. In PSO every particle stores all its coordinates for availing better solution. As per calculating fitness function of each particle and best valueis stored. Pbest is known as fitness value of current position of particle. lbest is localbest will obtained by particle flying with neighbors and also its location. gbest is best value obtained by particles in neighbor of that particles in PSO for calculating optimal solutions of optimization.

A. Cluster Formation

The clustering is a group of sensor nodes and this cluster formed by base station. The base station is broadcasting to cluster nodes collection of data from cluster nodes. The response given by sensor nodes by giving appropriate information as sensor node id, location of node based on position, distance from base station, residual energy of node etc. After receiving particular information by nodes then base station starts clustering approach as per following steps.

- Step1-Particle Swarm Optimization having particle position and velocity dimensions for conversion of problem in PSO available area.
- Step2-By using fitness function calculate approximate value

B. Fitness function

Fitness function based on clustering to optimize avg distance, avg energy of member nodes and calculate head count by applying Particle Swarm Optimization (PSO).

By applying following formula, fitness value is generated for particles.

Fitness value = FV =**β** 1

$$\frac{\sum_{i=0}^{N} d=(node_{current}, mem_i)}{n} + \beta_2$$

$$\frac{\sum_{i=0}^{n} E=(mem_i)}{E\,(node_{current})} + (1-\beta_1-\beta_2)$$

$$\frac{1}{\text{No. of members } (mem_i\ )\text{covered by current node}(node_{current})}$$

In above fitness function, **β**1 and **β**2 = weighing parameters.

n= The cluster having the no. of members

Step3- By initial solutions we can produce new particles. The newly produced particles are getting from old one.

As per the current velocity of particles we can estimate new velocity of a particle for that particles position will be changed other position. As per this the velocity is calculations as like below.

new velocity = ***η**** old velocity
+***η*** 1(local_best_position – current_best_position)
+***η*** 2(global_best_position – current_best_position),

In above η= inertia weight and $\eta 1$ and $\eta 2$ are tuning parameters in particle swarm optimization.

The particle's new position estimation as below:
new position = old position + new velocity
Step4 – Fitness value of new particles calculate as follows.
In step -2 by applying new velocity and new position the fitness value of new particles is analyzed.
Step5 - The best fitness value is selected for next iteration based on comparison of old particle's and new particle's fitness value.
If new FV > old FV
select new particle;
else
old particle is forwarded to next iteration.
Step6- The best local solution is selected for each iteration. The chosen lbest solution is as per the particle's maximum fitness value in current iteration.
Step7 - The global best solution is selected for each iteration. The chosen global solution is getting from local best solutions from alliterations in that maximum of all solutions.

In particle swarm optimization the clustering approach is chosen by base station. And broadcasting message that contain cluster member, cluster head. To perform cluster head selection, every sensor node store the message sent broadcast by base station and as per message every sensor node initiate for rounding procedure.

C. Cluster Head Selection by PSO -
A successful implementation of clustering process, every sensor node having maintaining cluster_id, node_velocity, node_location, node_energy. By initiating rounds to perform cluster head selection by Particle Swarm Optimization(PSO) the process as per steps inform below.
Step1- The current sensor_node's neighbour node are communication with each other for selecting energy efficient cluster head.
Step2- Fitness function for selecting energy efficient cluster head.

Fitness value = $F_v = \beta 1$

$$\frac{\sum_{i=0}^{m} d(node_{current}, mem_i)}{n}\gamma + \beta_2 \frac{\sum_{i=0}^{m} E(mem_i)}{E(node_{current})} + (1-\beta_1-\beta_2)\frac{1}{\text{Number of members } (mem_i) \text{ covered by current node} (node_{current})}$$

γ = 1 if member i is covered by current node
γ = 0, else
m= number of members in the current cluster node
β_1, β_2 = weighting parameters
n = number of members within range

Step3- From the initial solution the process of generation of new particles. The following steps shows how to approximate new velocity.

New velocity = η*old velocity
+$\eta 1$(local_best_position – current_best_position)
+ $\eta 2$(global_best_position – current_best_position)

η = is inertia weight
$\eta 1$ and $\eta 2$ = the basic PSO tuning parameters.

By using new velocity approximate new position as below
New position = old position + new velocity
New position above process new particle i.e. new velocity and new position appears.

Step4. New particles's fitness value calculation

By using fitness function the new particles fitness value is calculated by follow step2 of new velocity and new position.

Step5- The best fitness value is selected as per comparing fitness of old particle and new particle.

if new FV> old FV
select new particle;
else
old particle is forwarded to next iteration

Step6- One of the best solution are selected and calculated as a local best solution for every iteration. The lbest solution have been selected as per which particle is possess maximum fitness value for current iteration.
Step 7 - The global best solution is found as per which having maximum among all local_best solutions selection. As per above process of iterations, which particle having a global_best solution as selected as current cluster head.

D. Data transmission by using multi-hop routing protocol

In intra-cluster multihop clustering approach, packet forwarding to cluster-head based on selection of neighboring node restrict forwarding for which reducing the energy consumption is main aim.

The routing perform within two steps. Firstly, establishment of route, secondly forwarding of sensed data packet. On demand distance vector routing protocol to setup of route in between two sensor nodes. This process is contain establishment of initial route, unavailability of route. In establishment of route phase, broadcast the route request message to all nodes for one-hop transmission[11]. Unicast routing message have sent to reverse path to source node. After establishment of route, data transmission commence with the multi-hop routing. For this process, for data transmission from sensor nodes to cluster head after that from cluster head to base station have been done by multi-hop communication protocol[12-15].

For saving residual energy of sensor node and setting threshold value (d) done by data aggregation by cluster head of every cluster. The cluster head starts to transmission data to head by single hop-transmission done when the transmission distance is shorter in between cluster head to sink node is lesser than threshold value. Or otherwise, cluster head find relay node as a neighbour node for next hop with minimum cost [16]. The chosen relay node as a neighbor node based on residual energy (remaining energy of a node). The calculations of less cost path high remaining energy of a node by applying formula is...

$$Cst(b) = \boldsymbol{\eta} ** \frac{d(s_a,s_b)2 + d(s_b,LN)2}{\max(d(s_a,s_b)2 + d(s_b,LN)2} + (1-\boldsymbol{\eta}) * \frac{\max(Energy(b)) - Energy(b)}{\max(Energy(b))},$$

$$\boldsymbol{\eta} \in [0, 1],$$

$\boldsymbol{\eta}$= randomized tuning parameter
s_a,s_b= the member node and current head node
LN = link node

Once cluster head is selected, for sending data from source to destination with inter-cluster route the relay cluster head node is selected.

III. RESLULTS AND DISCUSSION

The Operating System Ubuntu 14.04 LTS and NS 2.34 Network Simulator and by applying PSO algorithm in clustering approach for (IoT applications) to perform network performance for minimize energy conservation of sensor node devices. The Operating System Ubuntu 14.04 LTS and NS 2.34 Network Simulator and by applying PSO algorithm in clustering approach for (IoT applications) to perform network performance for minimize energy conservation of sensor node devices by deploying 100 nodes within 200 x 200 squire meter area. As per following metrics, the simulation results are evaluated.

1. Total No. of Packets received - It is calculated as total no. of packets send by cluster head (source) as well as received by base station(destination). In fig1 number of packets received by base station for taken rounds 50,100,150,200. As per results, the packets received by Base station in enhance PSOEEC while compare with Competitive Clustering Algorithm.

Simulation parameters as follows…

Simulation parameters:

Number of iterations	100
Number of nodes	100
Area(deployment)	200 * 200Sqm.
Initial energy	3joules
Energy indulgence to run the radio device(E_{elec})	50n joule/bit.
Coverage area	91metre^2.
MACtype	802.11.
Antenna_model	Omni-Direction-Antenna.
Propagation_model	Freespace/two-ray ground.
Queue_type	Priority-queue
Transmission_power	0.02watts.
Receiving_power	0.01watts.
Application_type	Sensing-application (temperature).
Connection_type	User Datagram Protocol(UDP).
Transmission_duration	155seconds.
Simulation_time	200sec.

TABLE 1- No. of Packets received

Total No. of rounds	No. of Packets received	
	CC	PSOEEC
50	103	110
100	595	620
150	1086	1120
200	1521	1545

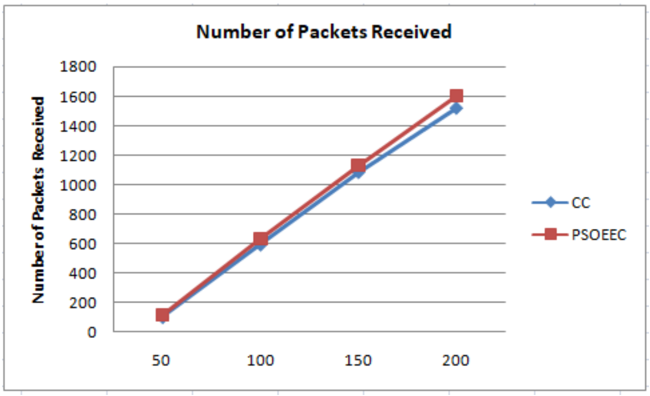

Fig2 – No. of packets received

2. Packet Delivery Ratio - The total no. of packets received as per total no. of packets transmitted. In fig2 showing packet delivery ratio for taken rounds 50,100,150,200. As per results, the packets delivery ratio by PSOEEC algorithm more than Competitive Clustering Algorithm.

TABLE 2- No. of Packet Delivery Ratio(PDR)

Total No. of rounds	No. of Packets received	
	CC	PSOEEC
50	68.21	75.25
100	91.26	93.10
150	94.93	96.40
200	96.02	97.12

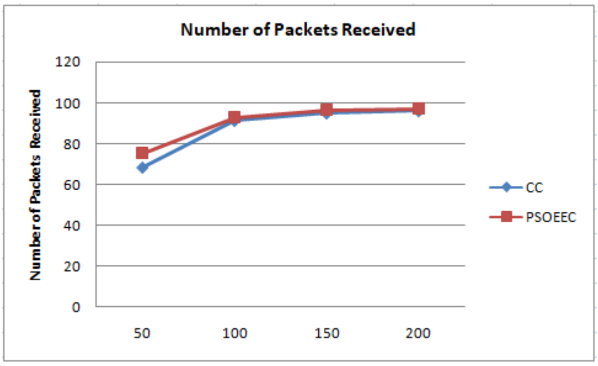

Fig3 - No. of Packet Delivery Ratio (PDR)

3. End-to-End delay - To routing a packet calculated as average time taken in seconds from source sensor node to target sensor node is denoted as End-to-End delay. Simulation results showing end-to-end delay of routing in PSOEEC is lesser than Competitive cluster algorithm.

TABLE 3 - End-To-Delay

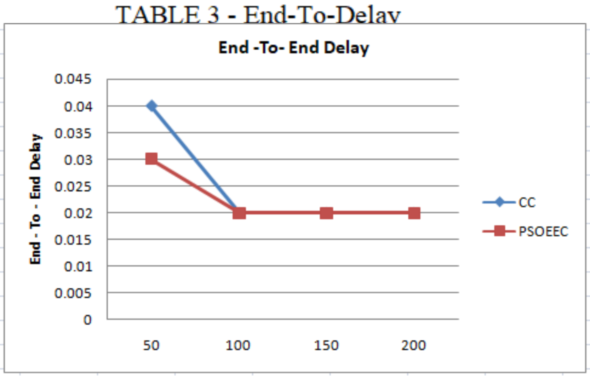

Fig4 - End-to-End delay

4. Throughput (b/s) - Throughput measure for transmission of total no. of packets per second. In simulation results in throughput of packets in PSOEEC showing more efficiency than Competitive cluster algorithm.

TABLE 4 - Throughput

Total No. of rounds	Throughput (b/s)	
	CC	PSOEEC
50	28541.60	30605.4
100	37724.50	38597.8
150	38789.50	38977.9
200	39438.90	40100.5

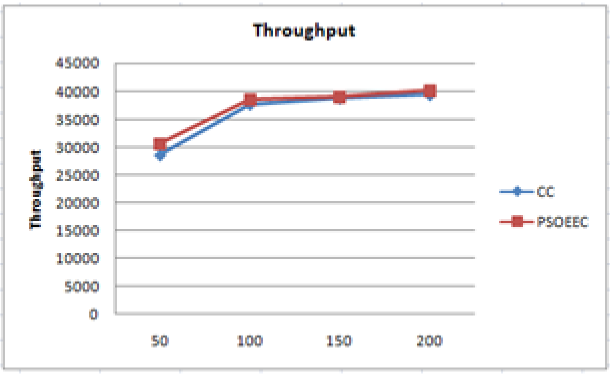

Fig5 – Throughput

5. Number of packets drop - It calculated by difference of total no. of data packets sent and total number of packets received. In simulation results, by applying PSOEEC packets drop is lesser than Competitive clustering algorithm.

TABLE 5 - Number of Packets Drop

Total No. of rounds	No. of Packets Drop	
	CC	PSOEEC
50	48	30
100	57	31
150	58	27
200	63	25

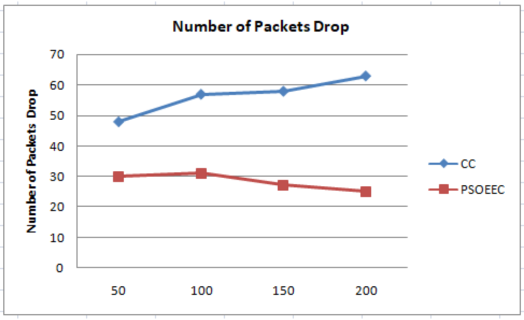

Fig6- No. of Packets drop

6. Network lifetime - The calculation of time which the first sensor node not-operation condition happened owing to battery power discharge. And also consider number of actives sensor-nodes at every-round consider. By showing simulation results, by PSOEEC lifetime of network increases by less consuming of energy of every node by having cluster-head selection. While comparing with Competitive clustering algorithm, PSOEEC showing better performance for increase network lifetime.

TABLE 6 - Network Lifetime

Total No. of rounds	Network lifetime	
	CC	PSOEEC
50	13983.80	22252.2
100	6697.76	10493.0
150	4842.70	6997.25
200	3944.72	5273.95

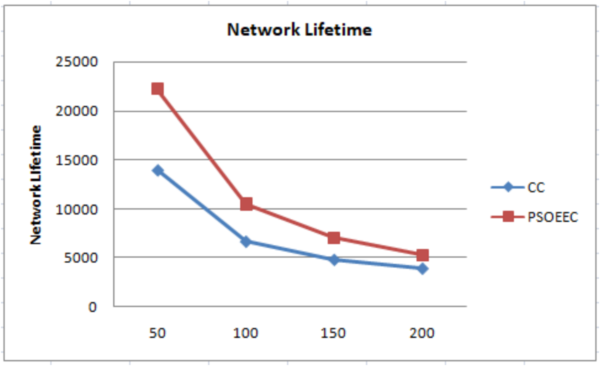

Fig7 – Network lifetime

7. Total Energy Consumption - It count for total amount of energy used by sensor nodes for transferring the data packets. Simulation results showing better performance in PSOEEC total energy consumption is decreased while transmit packets while comparing with CC.

TABLE 7 - Total Energy Consumption

Total No. of rounds	Total Energy Consumption	
	CC	PSOEEC
50	4.25	2.15
100	8.87	4.23
150	12.27	6.45
200	15.06	8.50

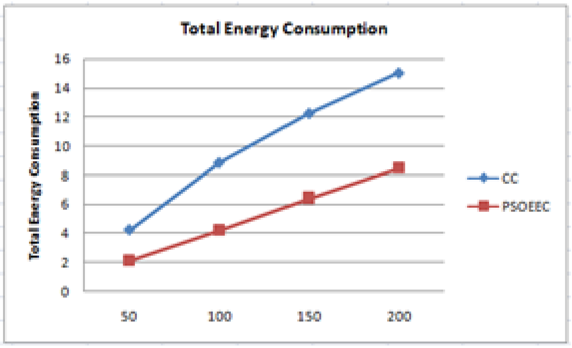

Fig8 – Total energy consumption

8. Average Residual Energy – Average-Residual-Energy considered as sensor nodes' remaining energy as per total-time. Simulation results showing about average residual energy enhanced in PSOEEC when comparing with competitive clustering.

TABLE 8 - Average Residual Energy

Total No. of rounds	Average Residual Energy	
	CC	PSOEEC
50	2.96	2.97
100	2.91	2.93
150	2.88	2.90
200	2.85	2.88

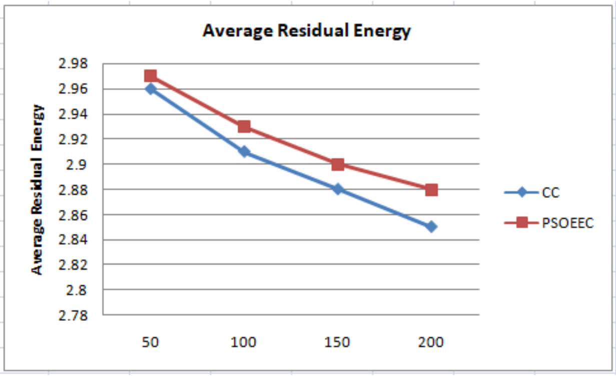

Fig9 – Average residual energy

In Internet of Things(IoT) applications, about implementation of clustering and energy efficient cluster head selection has been proposed for enhance throughput, residual energy (remaining energy of a node), packet delivery, maximize active nodes by applying PSOEEC algorithm. The performance metrics like throughput, network_lifetime, packet_delivery ratio, remaining energy, total-energy-consumption are implemented. These results comparison with competitive clustering algorithm(CC). The results showing high performance of proposed algorithm PSOEEC for minimize energy consumption in clustering for Internet of Things applications.

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