# FUZZY ACO BASED DEGREE OF CENTRALITY FOR ENERGY EFFECIENT DATA AGGREGATION IN WSN

**S.Vijaya Chandra***

**Dr. K. Alagarsamy****

## ABSTRACT

Wireless Sensor Network (WSN) main task is to sense and describe the actions of the physical world. In the majority of cases, sensor nodes are battery powered with restricted energy resources. Existing Hybrid Ant-hierarchical Fuzzy (HAF) model on road traffic system manages the traffic but not introduced the fuzzy set rules in HAF model to develop a consistent system. Other existing work Fuzzy-Rule-based systems using Continuous Ant-Colony Optimization (RCACO) uses the online rule generation process but does not provide the optimized result while verifying the effectiveness and efficiency of RCACO. To develop a consistent wireless sensor system for data aggregation, Fuzzy Ant Colony Optimized Clustering (FACOC) is introduced in this paper. FACOC based on the Node Degree Centrality is developed for the effective dynamic clustering with cluster head. Fuzzy ant colony clustering facilitate same sensor node in more than one cluster with different degree of membership function, which inherently support overlapping operation. Overlapping operation improve the flexibility of fuzzy ant colony clustering during the sensor node failure. FACOC offers the multiple route paths between each pair of overlapping in sensor network. Node Degree Centrality in FACOC defines the number of vertices links (i.e.,) ant paths upon a sensor nodes. The FACOC mechanism performs computation from simple marginal degree to distances along Euclidean center axes for energy effective data aggregation. The FACOC mechanism provides the best result by determining the optimal number of clusters

* Research Scholar, Manonmaniam Sundaranar University, Tirunelveli, Tamilnadu, India.

** Associate Professor, Department of Computer Applications, School of Information Technology ,M.K University, Madurai, Tamilnadu, India

using fuzzy form. In a large sensor network, FACOC data aggregation approximately decreases the energy consumption up to 12 % averagely and offers the reliable communication. The simulation result demonstrates that FACOC performs better on degree centrality based clustering efficiency, execution time, and energy consumption.

## I. Introduction

WSN is becoming a significant part for data aggregation because of the availability of recent advanced technologies in the sensor areas. Sensor nodes in commonly powered by small batteries and that are hard to replace or recharge. As a result energy limitation is a main challenge for broad remote applications. In a typical wireless enabled sensor system, energy consumption occurs in three fields specifically sensing, information processing and communication.

Cluster-based network organization based on set of coverage-aware cost metrics in [3] positions a compactly populated sensor network. Clustering main intension is to conserve the energy and preserve the coverage but the camera based coverage approach is not employed in the wireless sensor network. Cluster-tree repair algorithm as illustrated in [11] associates the nodes together and selects the cluster head. Cluster associate node is elected to maintain the cluster-tree topology but the real implementation using a test bed environment is not carried out.

Cluster based routing protocol in Delay- Tolerant Mobile Networks (DTMN) in [7] utilizes an on-line updating node strategy for the end to end routing. DTMN faces traffic load as the critical issues in sensor network. Computational Intelligence merges the learning elements together in [9] for addressing the effective clustering in wireless sensor network. The data aggregation and fusion protocols do not ensemble on these network architectures.

Game theoretic approach is demonstrated in [6] for selecting a cluster head for every cluster in a WSN. The multiple copy routing problems is solved using the spray routing as shown in [5]. But the spray routing is not effective over the multiple copies routing in a parallel fashion. Ensemble Based System (EBS) as described in [8] encloses the five diverse binary classifiers in sensor network. Existing Hybrid Ant-hierarchical Fuzzy (HAF) model as demonstrated in [1] manages the traffic but not introduced the fuzzy set rules in HAF model to develop a consistent system.

In this work, focus is made on developing an energy effective data aggregation using the Fuzzy Ant Colony Optimized Clustering mechanism. The FACOC uses the node degree centrality value to choose the cluster head among the clustered sensor nodes. The FACOC computes the degree membership function on each cluster to reduce the network failure rate.

The structure of this paper is as follows. In Section 1, describes the basic problems in data aggregation based on the fuzzy system and their limitations. In Section 2, present an overall view of the FACOC mechanism. Section 3 and 4 outline experiment results with parametric factors. Finally, Section 5 demonstrates the related work and Section 6 concludes the work.

## II.Fuzzy Ant Colony Optimized Clustering Mechanism in WSN

The main objective of the proposed work is to cluster the sensor nodes for the data aggregation using the Fuzzy Ant Colony Optimization procedure. The sensed data in the wireless sensor network transmits the information to the base station regularly for monitoring the traffic system. The traffic system presents an energy effective data aggregation system using the Fuzzy Ant Colony Optimization clustering.

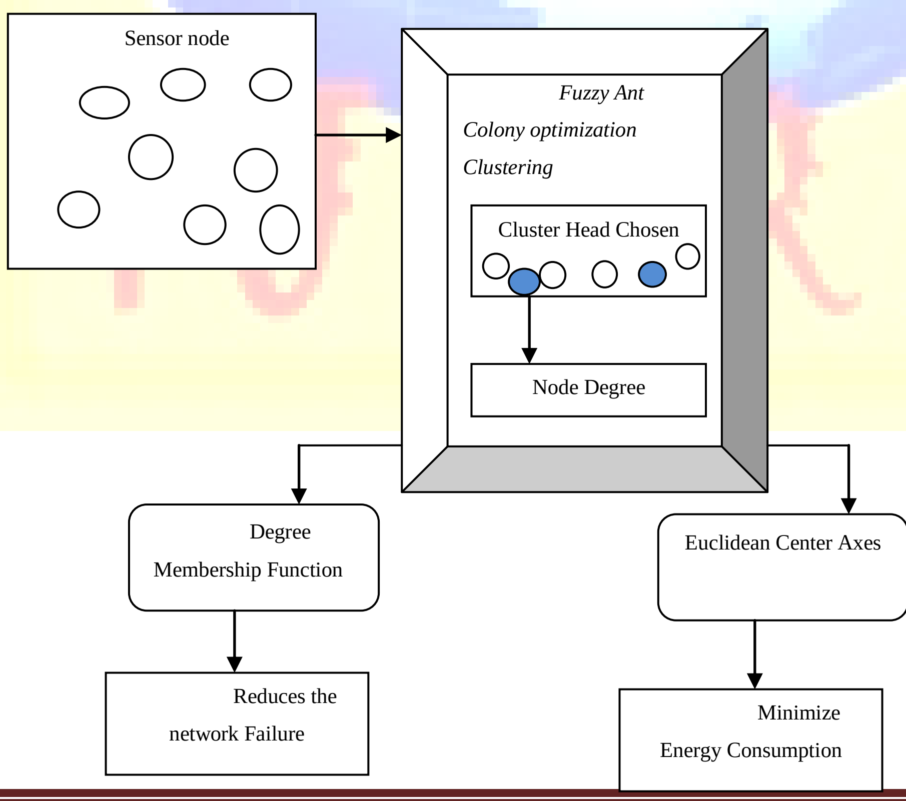

**Fig 1 Flow Diagram of FACOC**

Initially ant colony optimization is applied in sensor network to monitor the pheromone level on each route path and perform the clustering based on the fuzzy rule. The sensor position is projected along the 'x' and 'y' coordinates in FACOC mechanism to easily monitor the marginal degree sensor nodes. The marginal degree sensor nodes use the Euclidean center axes for the energy effective data aggregation. Flow diagram of FACOC mechanism is described in Fig 1.

As illustrated in Fig 1, FACOC mechanism takes the sensor nodes for the energy effective data aggregation. The fuzzy ant colony optimized clustering chooses the cluster head based on the node degree centrality. The node degree centrality uses the isomorphic graphs for easy choosing of cluster head in wireless sensor network. The isomorphic graphs maps the vertex set depending of the pheromone level on the route path and measures the position of a sensor node along a predefined set of ant routes.

The sensor node position is measured based on degree centrality and chooses the cluster head for the each cluster group in wireless sensor network with Euclidean center axes distance measure. The degree membership function is computed and used for reducing the network failure rate. The same sensor node is used for the different path establishment in the sensor network, so that the same sensor node in more than one cluster is placed by computing the membership function. The FACOC mechanism computes the distance based on the Euclidean center axes for the minimal energy consumption while clustering.

## Selection of Cluster Head

The cluster head is elected based on the node degree centrality concept in FACOC mechanism. The degree node centrality defines the link route vertices among the sensor nodes for choosing the cluster head. FACOC mechanism degree of centrality is computed as,

$$Degree\ of\ centrality = D_g(V1, V2, V3..Vn) \qquad \text{…………… Eqn (1)}$$

$D_g$ is the degree of the graph with the different vertex nodes. $V1, V2, V3..Vn$ denotes vertices in sensor network. Isomorphism Graph (IG) is used to find the high degree of centrality between the vertices (i.e.,) nodes. The high degree centrality node is chosen as the cluster head node in FACOC mechanism. The isomorphism graph based node degree computation is

$$IG = \sum_{i=1}^{n} D_g(V1_n) \qquad \ldots\ldots\ldots\ldots \text{ Eqn (2)}$$

The degree value of each vertex is computed from the 'n' set of sensor nodes and the higher degree value is marked as the centrality node in FACOC mechanism. The centrality node is taken as the cluster head node in the Fuzzy Ant Colony optimized Clustering. The selection of cluster head based on the node degree centrality is represented through Fig 2.

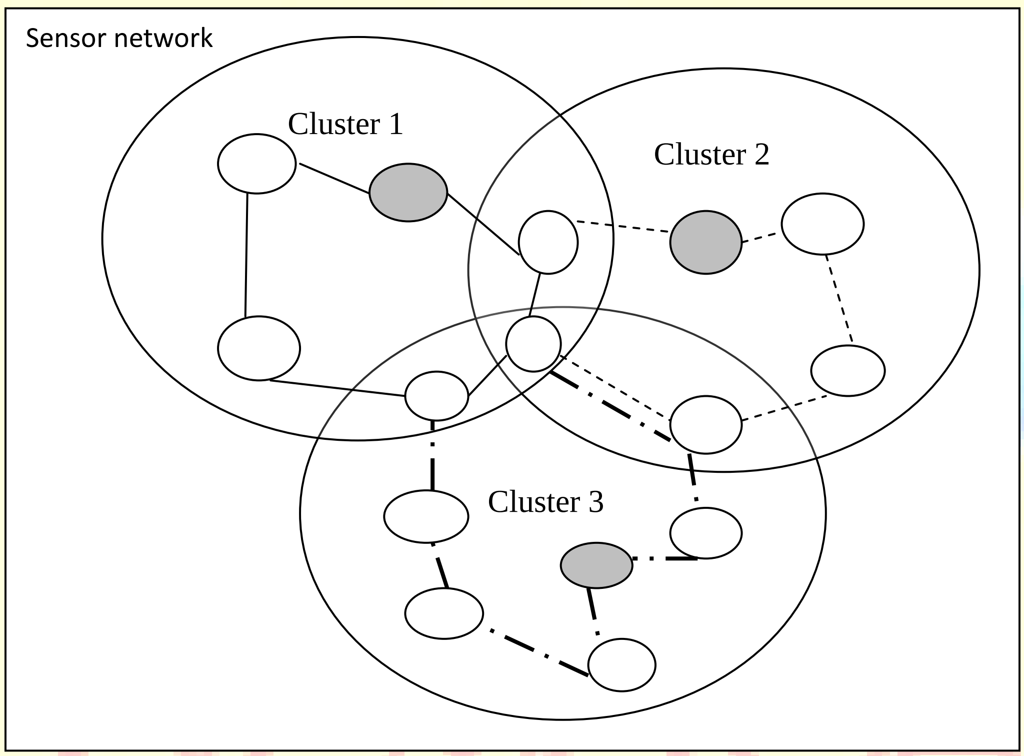


**Fig 2 Cluster Head Selection in FACOC mechanism**

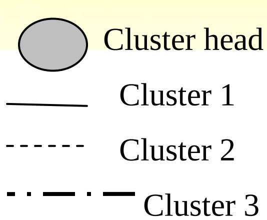


Fig 2 describes the cluster head selection on the cluster 1, 2, 3 of the sensor network. The cluster head selection is performed based on the node degree centrality result. Each cluster nodes are represented through the different connection lines. The optimized clustering reduces the network failure rate using the overlapping operation in the FACOC mechanism. The disconnection of one network ant path can be replaced by the alter path through this overlapping of nodes on the different clusters. The overlapping of same nodes on the different cluster group leads to improve the scalability ratio in the FACOC wireless sensor network.

## Degree Membership Function

Fuzzy Ant colony Optimized Clustering in WSN facilitates the node to more than one cluster with the different degree of membership function. The degree membership function effectively supports the overlapping operation. The overlapping operation in the fuzzy ant colony optimized clustering provides the multiple paths to manage the traffic effectively with optimized result in WSN.

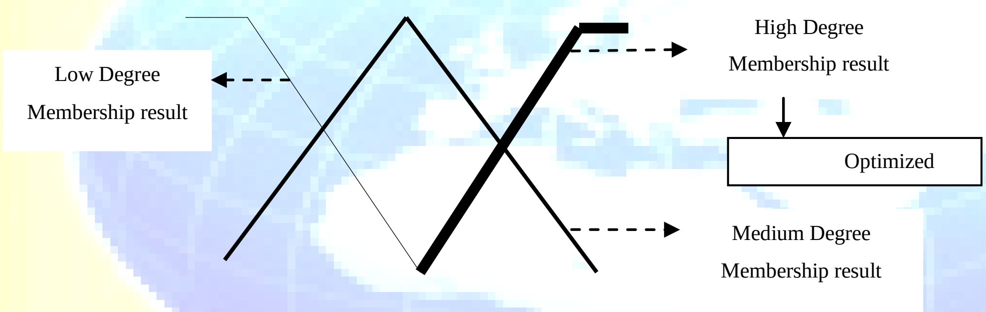


**Fig 3 Degree Membership Function Graph**

Fig 3 illustrates the degree membership function with graph values. The graph denotes the low, medium and high membership function values. Assume the 'n' sensor nodes in an x*y sensor network field. Each node in the sensor field is mapped to any one of the cluster based on the membership function value.

Consider data 'D' transferred through the vector '$v_K$' where k=1,2,…n. The vector (i.e.,) node is partitioned into the $n_s$ clusters with the fuzzy ant colony based optimization. The vector $s_i = s_{i1,}s_{i2,\dots}s_{in}$ is used for computing the fuzzy set under the following constraints in FACOC mechanism. The constrains for the degree membership value computation is that,

$\sum_{i=1}^{n} \mu_{xy}$ <1, then the degree membership function is computed as low

$\sum_{i=1}^{n} \mu_{xy}$ =1, then the degree membership function is computed as medium

$\sum_{i=1}^{n} \mu_{xy}$ <1, then the degree membership function is computed as high (i.e.,) positive Function value

$\mu_{xy}$denotes the membership function 'μ' on the network field 'x' and 'y'. The network field with 'n' sensor nodes computes the membership function and identifies the node which tries to destroy the network path (or) traffic occurring node. The membership function with the negative value is the traffic created node and finally FACOC reduces the network failure rate in WSN.

## Euclidean Distance in FACOC

Fuzzy ant colony optimization takes the input data and determines the degree centrality of the each cluster group. The network field performs the energy effective data aggregation using the Euclidean center axes distance measure. Any sensor node at distance function is computed as,

$$Euclidean\ distance\ (D_g, r) = \sqrt{(s_{i1} - r_1)^2 + (s_{i2} - r_2)^2 + \dots \dots + (s_{in} - r_n)^2} \quad \text{...Eqn (3)}$$

The 'r' is the radii point from the node centrality. The data aggregation with $s_{i1}$, $s_{i2}$,… $s_{in}$ vector nodes easily cluster all the marginal nodes with minimal energy consumption. For the degree membership function computation, each cluster and the cluster head nodes are used. The cluster head hold the information about all the cluster nodes and perform the aggregation process. The fuzzy ant colony optimization consists of a node degree centrality, membership function and Euclidean center distance measurement. The algorithmic step of the FACOC mechanism is described as,

Input: Network area x*y containing all the sensor nodes 'n'

Output: Energy Effective data aggregation in WSN

Step 1: Construct the sensor network with vector 'v' and edge points 'e' based on input variables

**//Degree Node Centrality**

Step 2: Selects cluster head based on $D_g(V1, V2, V3..Vn)$ computation

Step 3: Isomorphism graph based node degree computation

Step 4: Overlapping of nodes in WSN produces the optimized result

**//Membership Function**

Step 5: Compute the degree membership function with constrained factors

Step 6: Fuzzy Ant Colony Rule offers multiple path to manage the traffic system

Step 7: Fuzzy Ant colony Optimized reduces the network failure rate

**//Euclidean Distance Measure**

Step 8: Euclidean distance employed to find $\sqrt{(s_{i1}-r_1)^2+(s_{i2}-r_2)^2+\ldots\ldots+(s_{in}-r_n)^2}$ distance of marginal sensor nodes from the node centrality

Step 9: Sensor node aggregate the nearest cluster nodes with minimum Euclidean distance to reduce energy consumption

Step 10: Process of unification the outputs with energy effective data aggregation

The above algorithm for FACOC mechanism selects the cluster head from the group of sensor nodes by using the fuzzy based degree node centrality. The overlapping operation in the FACOC mechanism reduces the network failure rate by connecting the same node to the different cluster group based on the membership function value. The membership function value is computed based in the constrained factor. The marginal degree of sensor nodes are used to compute the energy effective data aggregation using the Euclidean center distance axes measure with radii value.

## Experimental Evaluation of FACOC Mechanism

FACOC in wireless sensor network is experimented using the ns-2 network simulator. The network size chosen for the experimental work is about 900 ×900 size. FACOC hold 30 (m/s) simulation results. Random Waypoint Model (RWM) model shifts to an erratically chosen location. RWM uses average about 100 number of sensor nodes for data aggregation. Dynamic Source Routing (DSR) Protocol is used in FACOC for the data aggregation with the minimal energy consumption. The minimum moving speed is about 5.0 m/s of each sensed node.

Scalability is defined as the ability of the system to handle the data aggregation process growing amount of sensor nodes in wireless network. Data aggregation time is defined as the amount of time taken to aggregate the data in wireless sensor network using the Fuzzy Any Colony optimized Clustering.

$$DGT = Aggregation\ Start\ Time - End\ Time$$

DGT is the Data aggregation rate and Aggregation time is measured in terms of milliseconds (ms).

## III. FACOC Result Analysis

In section 4, FACOC mechanism results are analyzed on the existing Hybrid Ant-hierarchical Fuzzy (HAF) model and Fuzzy-Rule-based systems using Continuous Ant-Colony Optimization (RCACO).

| Technique | Scalability (%) |
|---|---|
| HAF model | 85 |
| RCACO | 87 |
| FACOC mechanism | 95 |

**Table 3 Tabulation of Scalability**

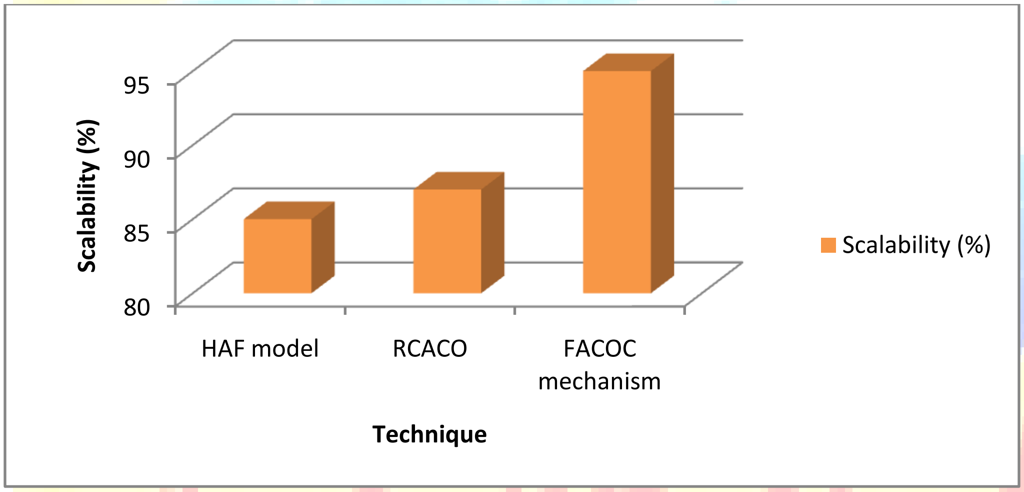


**Fig 6 Measure of Scalability**

Fig 6 describes the scalability percentage value of the HAF model, RCACO and FACOC mechanism. The overlapping operation in FACOC mechanism for improves the scalability ratio. The scalability ratio is improved by 7 % when compared with the RCACO method [2]. The overlapping operation in the fuzzy ant colony optimized clustering provides the multiple paths to manage the traffic effectively and improve the scalability ratio by 10 % when compared with the HAF model [1] in wireless sensor network.

| Data Size (KB) | Data Aggregation Time (sec) | | |
|---|---|---|---|
| | HAF | RCACO | FACOC |
| 50 | 92 | 89 | 80 |
| 100 | 112 | 106 | 95 |
| 150 | 139 | 121 | 111 |
| 200 | 135 | 126 | 113 |
| 250 | 156 | 149 | 134 |
| 300 | 179 | 165 | 150 |
| 350 | 222 | 203 | 189 |

**Table 5 Data Aggregation Time**

Table 5 describes the data aggregation time of the different method through tabulation. The data aggregation time of the HAF model [1], RCACO [2] are compared with the proposed FACOC mechanism. Depending on the data size, the aggregation time is varied in the wireless sensor network.

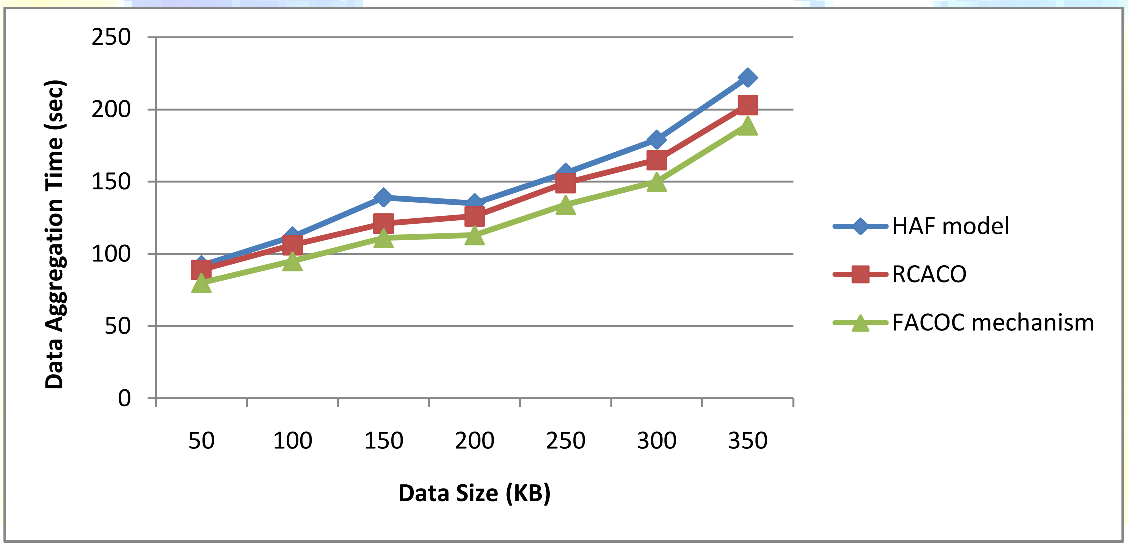


**Fig 8 Data Aggregation Time Measure**

Fig 8 describes the data aggregation measure based on the data size. The degree membership function computation is used for the aggregation of the data in a minimal time. The aggregated data consumes 13 – 20 % less time in FACOC mechanism when compared with the

HAF model [1]. The aggregation time is also reduced about 6 – 10 % in FACOC mechanism when compared with the RCACO method [2].

Finally, Fuzzy Ant Colony Optimized Clustering mechanism develops an energy effective data aggregation process in wireless sensor network.

## IV.Related Work

WSN provides the real time dynamic system with limited energy computation and memory resources. Fuzzy logic approach as demonstrated in [10] applies the equivalent membership functions using the fuzzy linguistic variables. The drawback of using fuzzy logic is that rule store the base necessitates consumes more memory for storing the fuzzy result.

Fuzzy-Rule-based systems using Continuous Ant-Colony Optimization (RCACO) in [2] uses the online ruling generation process with the continuous domain path. RCACO does not provide the optimized outcome with effectiveness and efficiency result. As demonstrated in [4], Fuzzy Congestion Controller (FCC) in WSN detects the traffic and avoids the congestion. FCC not effective on the rate adjustment on the middle and sink nodes. To adjust the rate factor the degree node centrality is employed in the proposed FACOC mechanism.

## V.Conclusion

Fuzzy Ant Colony Optimized Clustering mechanism is presented with optimal umber of sensor nodes for providing the energy effective data aggregation in wireless sensor network. Consequently the cluster head is chosen with the fuzzy ant colony optimized clustering and the overlapping operation employed to reduce the network failure rate. Every node in the wireless sensor network takes part in the data aggregation process. The data aggregation time is also minimized in FACOC mechanism. The simulation result shows the effective scalability (7 %) higher when compared with the HAF model. FACOC data aggregation considerably decreases the energy consumption up to 10.59 % and offers the reliable communication.

## REFERENCES

[1] Habib M. Kammouna., Ilhem Kallel., Jorge Casillas., Ajith Abraham., Adel M. Alimi., "Adapt-Traf: An adaptive multiagent road traffic management system based on hybrid ant-hierarchical fuzzy model," Transportation Research Part C., Elsevier journal., 2014

[2] Chia-Feng Juang., and Po-Han Chang., "Designing Fuzzy-Rule-Based Systems Using Continuous Ant-Colony Optimization," IEEE TRANSACTIONS ON FUZZY SYSTEMS, VOL. 18, NO. 1, FEBRUARY 2010

[3] Stanislava Soro., Wendi B. Heinzelman., "Cluster head election techniques for coverage preservation in wireless sensor networks," Ad Hoc Networks, Elsevier journal, 2009

[4] M. Samimi., A. Rezaee., and M. H. Yaghmaee., "Design a New Fuzzy Congestion Controller in Wireless Sensor Networks," International Journal of Information and Electronics Engineering, Vol. 2, No. 3, May 2012

[5] Thrasyvoulos Spyropoulos., Konstantinos Psounis., and Cauligi S. Raghavendra., "Efficient Routing in Intermittently Connected Mobile Networks: The Multiple-Copy Case," IEEE/ACM TRANSACTIONS ON NETWORKING, VOL. 16, NO. 1, FEBRUARY 2008

[6] Sudakshina Dasgupta., Paramartha Dutta., "A Novel Game Theoretic Approach for Cluster Head Selection in WSN," International Journal of Innovative Technology and Exploring Engineering (IJITEE) ISSN: 2278-3075, Volume-2, Issue-3, February 2013

[7] Ha Dang., and Hongyi Wu., "Clustering and Cluster-Based Routing Protocol for Delay-Tolerant Mobile Networks," IEEE TRANSACTIONS ON WIRELESS COMMUNICATIONS, VOL. 9, NO. 6, JUNE 2010

[8] Daniel-Ioan Curiac., Constantin Volosencu., "Ensemble based sensing anomaly detection in wireless sensor networks," Expert Systems with Applications, Elsevier journal., 2012

[9] Muhammad Umar Farooq., "Computational Intelligence Based Data Aggregation Technique in Clustered WSN: Prospects and Considerations," Proceedings of the World Congress on Engineering and Computer Science 2012 Vol II, WCECS 2012, October 24-26, 2012

[10] Krasimira Kapitanova., Sang H. Son., Kyoung-Don Kang., "Using fuzzy logic for robust event detection in wireless sensor networks," Ad Hoc Networks., Elsevier Journal., 2012

[11] Xiaonan Wang and Huanyan Qian., "Constructing a 6LoWPAN Wireless Sensor Network Based on a Cluster Tree," IEEE TRANSACTIONS ON VEHICULAR TECHNOLOGY, VOL. 61, NO. 3, MARCH 2012