

# Fuzzy Based Data Gathering Model for Improving Network Lifetime in ADHOC Networking

K.Deeba, S.Tamizharasi, T.Vinoth Kumar

**Abstract:** In Adhoc Wireless Sensor Networks (AWSN), nodes are moving with less or high mobility. It is very difficult to Quality of Service (QoS) to achieve network performance. Paths can be identified based on network model and stable route formation. In a cluster region, data gathering ratio can be easily achieved but difficult to reach maximum level. In existing schemes, balancing between data gathering and security was not attained. In this paper, Fuzzy based Secure Data Gathering Approach (FSDGA) is proposed based on TDMA based scheduling and Asymmetric key crypto model. This approach consists of three phases. In first phase, cluster formation and cluster head election is done based on calculation of remaining energy and stability of nodes. In second phase, secure routes are identified with constant key metrics. In third phase, Fuzzy integrated Data transmission phase is installed to protect the data from attackers and improve the data collection rate. The performance of FSDGA is analysed using simulation tool in terms of energy conservation rate, propagation delay, data confidential rate, control overhead and data gathering ratio.

**Keywords -** WSN, FSDGA, cluster formation, secure routing, data collection, propagation delay and energy conservation rate.

## I. INTRODUCTION

### Adhoc Wireless Sensor Networks (AWSNs)

Sensor nodes consist of data processing unit, power unit and monitoring unit. Sensor nodes are organized in random manner and mainly used for surveillance and security applications. Including this, environmental effects are monitored and report it to control room. The information is collected, processed and transferred to sink node via multi-hop routing. It was widely deployed in home appliances, medical equipments and monitoring environmental conditions. Each sensor nodes has limited capability such as radio memory and power handling capacity. These nodes are usually operated and it may not be replaceable during energy balancing to extend the network lifetime and improve the data gathering rate. Energy conservation rate is an important factor in WSN but compared to Adhoc networks, sensor nodes consumes less energy due to less mobility. To reduce energy consumption, existing works had focused on spatial correlation between information gathering and

adaptive routing. In existing works, both emerging requirements of WSN i.e. privacy and security were focused by Fei Yu et.al [1] to protect the data from the attackers with recent technologies and protocols. The main aim of this analysis was to club all the researchers to make awareness on cloud distributing systems, crypto graphical methods, secure routing frameworks with the practical solutions to put an end to vulnerability in the network. The research had been extended towards to provide trade-off between security and dependability to achieve quality of service (QoS) in the presence of threats and challenging environment. Shehri [2] had made an analysis of WSN threats, issues, vulnerabilities and provided the methods such as cryptographic solutions, secure routing protocols and authenticated schemes to detect misbehaviour nodes as well as data protection. In this literature survey, various methods were thoroughly verified and analysed in terms of performance metrics based on network challenges. Attacks of WSN were identified in the each layer of WSN and provided the possible solutions to reduce these attacks with the best methods and protocols.

Data collection or gathering is a major function of sensor network where the data is sampled at sensor nodes and transferred to central node or authority for further processing. The in-data aggregation is required to provide solution for energy constraints and limited data transfer ability. The alternative approach is to process the data with limited power to reduce the expensive data transfer rate. The sensor nodes are geographically located to measure independent components at regular time intervals and forward these values to base station.

## II. LITERATURE SURVEY

Han and Li et.al [3] had introduced the concept of intermediate node based data gathering schemes with enhanced routing algorithm for three dimensional underwater sensor networks. An underwater vehicles or nodes are deployed to travel along the route to gather data from the intermediate nodes. Here the network was partitioned into grids to allow the nodes that enter into central location of all grids for data gathering. This structure was attained with predetermination of network deployment. All the autonomous nodes were allowed to visit the chosen region based on minimum probability of neighbourhood coverage distance to reduce the packet delay during data transmission. The introduced data gathering algorithm was focused on providing trade-off between data gathering delay and information gain based on transmission rounds. Liang et.al [4] implemented a secure transmission scheme with distributed data method to improve the network lifetime of WSN. The major building blocks of data transmission are divided into two types i.e. receiving node setup and choosing forwarding node from the setup.

**Revised Manuscript Received on October 15, 2019.**

**Dr.K.Deeba**, Computer Science and Engineering, Kalaigarnarunaniidhi Institute of Technology, Coimbatore, India. Email: deeba.senthil@gmail.com

**S.Tamizharasi**, Electronics and Communication Engineering, RVS College of Engineering and Technology, Coimbatore, India. Email id: tamilvino2011@gmail.com

**T.Vinoth Kumar**, Electrical and Electronics Engineering, RVS College of Engineering and Technology, Coimbatore, India. EMail id: tvinoth15f@gmail.com

## Fuzzy Based Data Gathering Model for Improving Network Lifetime in ADHOC Networking

It was achieved by implementing competitive mechanism with transit time and distance between the sensor nodes. It was also assumed that network model was deployed to increase the data transmission efficiency from the distribution of packets with secure routing. There are three model embedded in this distributed data transmission approach i.e. node competition model, data awareness model and reverse threat model. Including this, the security of packet transfer and node competition was also evaluated for WSN.

Chowdary and Satyanarayana [5] explored a data gathering approach for gathering information of all static and mobile sensor nodes in Wireless sensor and actor networks. From this method, the actor nodes store the data gradient values after computation in its actor node cache. Paths are discovered from actor node to sink nodes using path model by flooding route request packets through neighbour nodes. Multipath routing was also established from source to different actor intermediate nodes to reach the packets toward sink nodes to achieve load balancing and node efficiency in WSN. The recharge method was used to recharge the sensor nodes effectively from the data available in the actor nodes.

Alnuaimi et.al [6] proposed the ferry based data gathering algorithm by choosing paths to increase data delivery rate in WSN. It was implemented based on Node Ranking Clustering Algorithm (NRCA) to select nodes by providing ranks to all nodes and clusters. Cluster heads are assigned with individual ranks based on their performance to improve the data forwarding with least transfer time. The selection of CH was based on remaining energy and distance between node and base station. The ferry path check points were used to select the CH with high remaining energy. With this addition, data is gathered from ferry instead of network flooding through multi-hop routing.

Lu et.al [7] established an adaptive and distributed collision free MAC protocol from existing protocol. This protocol was integrated with Distributed Coordinate Function (DCF) based on WSN standard to build mesh based personal area networks. During packet transmission, channel collisions and noise were suppressed by means of introducing DCF metric to forward packets within an arrival time. Scheduling mechanism was adopted during route maintenance for allocating beacons in different slots with dimensions. From the performance analysis, it was analysed that performance of convergence time and packet overhead in the presence of channel collisions. Sylvie et.al [8] introduced the concept of geographical location of nodes and introduced deterministic position verification protocol for sensor network in the presence of network attackers. In general, while discovering a route from source to sink node, attackers may try to retrieve the location of sensor nodes to gather packet information. The outperforming nodes are located within the range of every node in the presence of arbitrary topology of the network. From the simulation it is seen that perfect nodes may have fake intermediate node to gather packets and misroute them. It was avoided by locating the nodes in protected zones with specific location metrics.

Abasi and Sajedi [9] designed a fuzzy based data gathering scheme in cluster region of sensor networks. High density clusters were deployed to increase the network span by choosing the better CHs. Data aggregation was done based on clustered routing and the concept of minimum spanning tree. The concept of fuzzy decision approach was used for

selection of CHs. After that, a spanning tree is established based on construction of clusters with potential CHs. The reason for adding clustering and spanning was to increase the data aggregation. This method was compared with different familiar data aggregation methods to improve remaining energy of sensor nodes.

Wang et.al [10] focused on various data gathering methods to improve WSN lifetime using the matrix completion of Graph Based Transform Regularized (GBTR). The different sensor datasets are used to analyze the topology information to increase the data aggregation from the matrix formulation. To retrieve the missed packets, alternate direction method of multipliers was used in the grid zone. From the analytical results, the graph based matrix achieved better recovery accuracy and low energy consumption than existing methods.

Almiani et.al [11] focused the problem of designing the mobile element path and routing tree to identify the path length with pre-estimated data constraints. A concept of tour mechanism was adopted for the nodes inside the region and multi-hop routing trees for packet creating that node covered in the tour region. The max flow computational methods were used to identify the bottlenecks in the network. In the network, data producing node will act as source node and sink node as destination to compute intermediate node to reduce traffic to save energy and to improve the network lifetime.

Jaishri, et.al [12] developed an analytical model to estimate network traffic load and to reduce energy consumption of sensor networks. The calculation was made on number of dead nodes, rising time and energy hole site during data gathering. In addition to this, polynomial time approximation method was also implemented to extend the time period of active nodes. Number of sensor nodes is reduced to cover the target points given by cluster regions. A Base station will keep on monitoring the activity of active and rising time period. A constant factor approximation algorithm was derived from the optimal solution inside the target point to develop coverage sensor factor.

Zhu et.al [13] had proven the data reliability from the cloud computing to WSN by aggregating the data from source to sink node. The analysis was made on data gathering ability, powerful data storage and data processing capacity in WSN. The critical issues were identified before offering the data reliability from sensor networks to cloud. Gateway of sensor network was used to transmit the sensory packets to the cloud by considering the time and data features of mobile user. Once it is adopted, the energy consumption of sensor networks was reduced to gather more packets in reliable manner.

Peng Sun et.al [14] had proposed a sparsen random sampling scheme for efficient data gathering in WSN. Nodes are organized into clusters with random subset of sub nodes to transfer the data measurements. Cluster head transmits the gathered data to destination node within cluster region. Data transmission can be absorbed from the selection of cluster head and data transfer through neighbour nodes. The relationship between cluster size and energy value can be observed using inter and intra cluster data gathering methods. The optimal size of clusters and transmission schemes was revealed based on the minimum energy cost factor.

Faigyl and Hollinger [15] developed an autonomous data collection scheme using self organizing map by providing a transformation of high dimension space into lower dimensional space. The concept of travelling salesman problem (TSP) was used with Self Organizing Map to provide a data solution for autonomous data collection. Nodes are moved within a limited communication range to gather data from pre-deployed sensors. The number of neurons were adapted during route discovery process to provide a trade-off between quality and computational requirements.

Pandey et.al [16] introduced the concept of Mobile ubiquitous LAN extensions (MULE) to provide the solution for node localization and data gathering. Mules are converted into conventional sensor network based on optimization. The low average path length and best clustering coefficient was identified in the small world sensor networks. The bandwidth requirement and localization error were reduced successfully using data collection procedure based on mule displacement and number of mules. The concept of multidimensional scaling method was used for cooperative localization of sensor nodes in the network region to increase joint localization and data gathering method.

Gu et.al [17] presented a novel data-gathering scheme with joint routing. The routing was adopted with compressive sensing to select next hop using remaining energy. The local optimal routing was adopted to speed the coverage ratio. The equivalent sensor matrix was designed using restricted isometric property to reduce the problems in the density network. The sensor signal was identified with diffusion wavelet's to prolong the network lifetime and to balance the load.

Zhu et.al [18] proposed a tree cluster based data gathering algorithm to increase the network lifetime of sensor network. A weight based tree was constructed using the destination node based on location of intermediate nodes and stable routing. Using rendezvous points, root nodes are constructed from sub rendezvous points to choose traffic loads and hops to the root nodes. After a certain period of time, data collection was achieved based on the selection of stop points of destination node with high mobility.

Kumar et. al[19], The paper is organized as follows. The Section 1 describes introduction about WSNs, data gathering and issues. Section 2 deals with the previous work which is related to the energy efficiency and data gathering algorithms. Section 3 is devoted for the implementation of proposed data gathering approach. Section 4 describes the performance analysis and the last section concludes the work.

### III. IMPLEMENTATION OF PROPOSED PROTOCOL

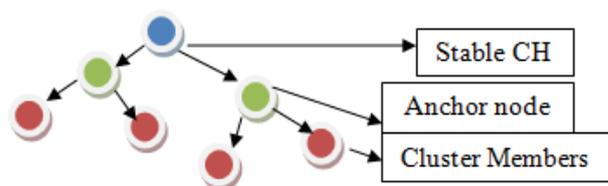
In the proposed scheme, Data gathering is completed successfully using Fuzzy integrated scheduling model. In the proposed structure, Stable CH and anchor nodes are used to monitor the behaviour of routes and nodes. The concept of TDMA schedule is adopted to provide data gathering from source to destination. Fig.1 illustrates the formation of stable cluster region. Cluster is formed based on high density of sensor nodes with position of static and dynamic to consume energy based on their mobility. Cluster head (CH) is chosen as ambassador of every cluster. Nodes in the cluster region will act as cluster members to gather

information about packets and routing and reporting it to nearby CH. While gathering information about the packets, more energy will be spent by cluster members. Energy optimization of the network is also adopted to balance power between transmitter and receiver.

#### Assumptions

The proposed Fuzzy integrated Data gathering WSN Structure consists of network model to check the environmental conditions by deploying cluster members in the target region. The following assumptions are made in this structure are as follows:

1. CH knows the location of cluster members and distribution of the location is random.
2. The deployed cluster members are scattered in the network.
3. The CH and anchor nodes are static i.e. once the located it will be immobile.
4. CH doesn't allow the energy limited nodes during the network deployment and route discovery process.
5. The distance between cluster member and CH is determined by means of RSSI (Received Signal Strength Indicator).
6. Cluster regions are deployed in the absence of Base Station (BS). CH has limitless power and handling capacity.
7. The distance between cluster members is used to adjust the transmission energy between transmitter and receiver.
8. Symmetric radio communication is used for packet transmission.
10. Due to energy exhaustion, failure of cluster member may occur in the region.
11. Anchor nodes generate the report about mobile sensor node and report it to CH.
12. The initial count of CHs is constant and it may change time to time according to network scenarios.



**Fig.1. Formation of Stable Cluster**

Cluster members in the network are located in the coverage area which is divided into four categories for energy conservation. The coverage area is considered as 1200 \* 1200 and the types of the categories are deployed based on mobility. Category 1 lies from 25 meter in X axis and 100 meter in Y axis for 50 m mobile nodes. Category 2 lies from 26 meter to 50 meter in X axis and 100 meter in Y axis for 75 m mobile nodes.

Category 3 lies from 51 meter to 76 meter in X axis and 100 meter in Y axis for 100 m mobile nodes. Nodes in the each region are assigned based on some probability of distance from CH.

### IV. PROPOSED APPROACH

Fuzzy based Secure Data Gathering Approach (FSDGA) is discussed using cluster routing. It consists of three steps. In first step, the best cluster member is chosen based on remaining energy and node stability.

In second step, density of nodes and packet forwarding capability of nodes are considered to balance energy and data gathering rate. In third step, security enhanced data transmission is initiated and adopted to protect node from attackers to save the gathered data. The proposed scheme is a distributed approach based on LEACH protocol. There are three phases:

1. Cluster formation phase
2. Secure Route Establishment phase
3. Fuzzy integrated Data Gathering Phase

### **Cluster formation phase**

Sensor nodes are grouped together to form a cluster region. Once the route discovery process is initiated, cluster formation process will be started based on data collection. In each phase, remaining energy and stability are calculated to form cluster region. In each region, CH is chosen as coordinator to check the route status and packet forwarding towards the destination node. After the deployment of cluster, CH broadcasts packet to the sink node. This packet contains location of cluster members, time slot for cluster member and node stability to reduce the collisions.

Cluster member broadcasts the message (Join\_pkt) with time period provided by CH to nullify the collision. After the route maintenance process, CH checks the status of node density, residual energy and distance from CM to CH. The following algorithm is used to create cluster region and cluster head election.

### **Secure Route Establishment Phase**

In this phase, CH broadcasts Hello\_Join Packets to all the cluster members and sink node. Anchor node checks the availability of CM report it to CH. CH records the route information of primary and alternative routes. CH uses multipath routing to forward packets in a short period of time. Density of CM is fixed by CH. Once Hello\_Join packets received by CM, it will send Route\_Join packets to CH to participate in data packet forwarding. There are three cluster groups maintained in this approach. In each group, single CH takes care of all administration work. CH<sub>1</sub> sends DEN\_KEY to CH<sub>2</sub> and CH<sub>3</sub>. Both cluster heads check the reliability of the key and decrypt the key using DDEC\_KEY. These keys are the private key and it will not be revealed to all members inside the region. Once decryption over, CH sends the data packet to remaining cluster heads through intermediate CMs. If any node violates the routing confidentiality, the anchor node immediately reports the scam of the packets and node to CH. CH will forward the packets through alternative routes.

### **Algorithm1: Formation of cluster and Selection of CH**

Start:

- Step 1: M total cluster member and anchor node (AN) in network  
 Step 2: K unique ID of CM and I Unique ID of AN  
 Step 3: Node  $(k).e \leftarrow e_0$   
 Step 4: Node  $(k).Stability \leftarrow CM$   
 Step 5: Stable CH\_data  $\leftarrow 0$   
 Step 6: Stable CH\_count  $\leftarrow N$   
 Step 7: Node (k).S  $\leftarrow$  Assign stability  
 Step 8: Node (i).T  $\leftarrow$  Transmission range of network  
 Step 9: While (Stable CH\_count  $\leq$  u%)  
 Step 10: {  
 Step 11: estimate eligibility parameter for each Node (i).  
 Step 12: estimate the average [EP]

- Step 13: estimate the threshold metric (TM) for Node (k)  
 Step 14: Generate Stability Index (SI) for each Node (k).  
 Step 15: If SI < Node (k).TM and Stable CH\_count < U% then  
 Step 16: Node (K).Stability  $\leftarrow$  Cluster\_head  
 Step 17: SCH\_count++  
 Step 18: Include Node (k) to CR\_group  
 Step 19: End If  
 Step 20: }  
 Step 21: Every CH sends SCH\_Msg (k, Rem\_Energy, SI) to each sensor node  
 Step 22: Node (k) joins nearest CH to form cluster  
 Quit

### **Fuzzy Integrated Data Gathering Approach**

The best candidate is chosen by fuzzy decision method and acts as the role of CH. Fuzzy model is the best one for decision making process and produces the maximum gain to achieve network performance. The structure of fuzzy inference system is illustrated in fig.

There are four building blocks of Fuzzy model.

**Fuzzifier:** In this block, crispy set is converted into fuzzy set and it is assigned with membership degree. The conversion of crisp value is done with Fuzzifier. The fuzzy set inputs are node density, distance and stability of nodes. The arbitration of membership function and intersection points are computed from the Fuzzifier.

**IF THEN rule:** IF THEN rules are used to analyse the performance of the dynamic system and it is also referred to as data support. All the membership values are fed to IF THEN rule base to check the conditions and obtain the union output and highlight the peak value. Mamdani fuzzy inference system is used to identify the network performance.

**Fuzzy Inference Engine:** This engine tries to execute the inference system of IF THEN rules to find the conclusion from the conditions from the rules. It processes the membership functions and produces the output. It will act as the input to defuzzifier.

**Defuzzification:** This process takes care of mapping between fuzzy set and crisp output to find the solution. The probability and centroid are calculated by defuzzifier. It converts the received input to crisp values and obtain the data gathering probability which will be either 0 or 1.

**Data gathering phase:** Once the formation of cluster and fuzzy model is done, CH tries to collect the data from the cluster members based on TDMA slot for collision free data forwarding. CH assigns the time slot to all the cluster members during the formation of cluster. Once all the information are received by CH, the information will be aligned to reduce the communication cost. TDMA schedule is estimated to forward the information to CH. Based on this operation, this algorithm completes first round successfully without interruption. In each round, the least hop distance from CM to CH is chosen based on link quality. The redundant data transmission is removed based on high data gathering rate. Sometimes the data transmission can be broken into frameworks once all cluster members are participated except CH. The synchronization pulses are sent to node by performing data aggregation to provide valuable data to CH. The minimum spanning tree is established for data aggregation from source to sink node.

## V. PERFORMANCE ANALYSIS

The following metrics are used to analyse the performance of WSN.

**Propagation delay:** The delay occurs due to propagation of packets from source to destination in entire route.

**Data Gathering Ratio:** It is the ratio of packet collected from target area to the number of packets distributed while consuming less energy.

**Control overhead:** It is defined as the ratio of control packets to the normalized packets.

**Data Confidential rate:** It is the rate at which number of genuine data packets travelling towards the sink node.

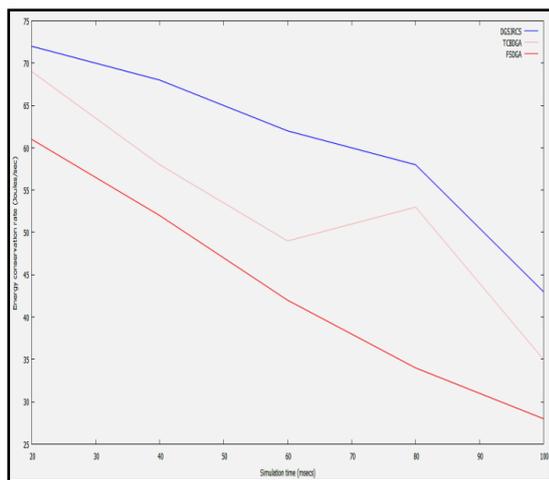
**Energy Conservation rate:** It is the rate at which the energy spent for transmitting a data from CH to CM.

The following results are taken from the trace file of our proposed approach FSDGA with previous schemes DGSJRCS [17] and TCBDGA [18].

The proposed approach is simulated with Network Simulator (NS 2.34) to analyze the performance with respect to existing schemes. In this simulation, 300 sensor nodes are divided into 3 cluster zones in a 1000 x 1000 sq.m. Static and mobile sensor nodes are held in the transmission range around 250 meter for simulation analysis. The simulation settings and parameters are summarized in table 1.

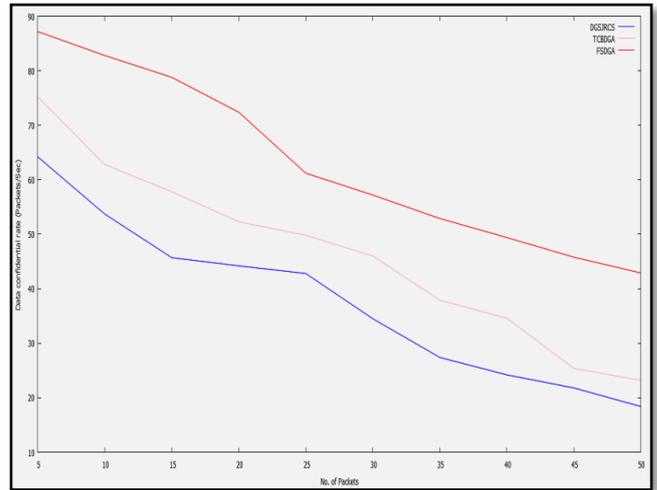
**Table 1. Simulation Settings and Parameters**

No. of Nodes	300
Area Size	1000 X 1000 sq.m
Mac	802.15.4
Radio Range	250m
Simulation Time	100 sec
Traffic Source	Poisson
Packet Size	512 bytes
Package rate	4 pkt/s
Protocol	LEACH
Mobility model	Random Walk



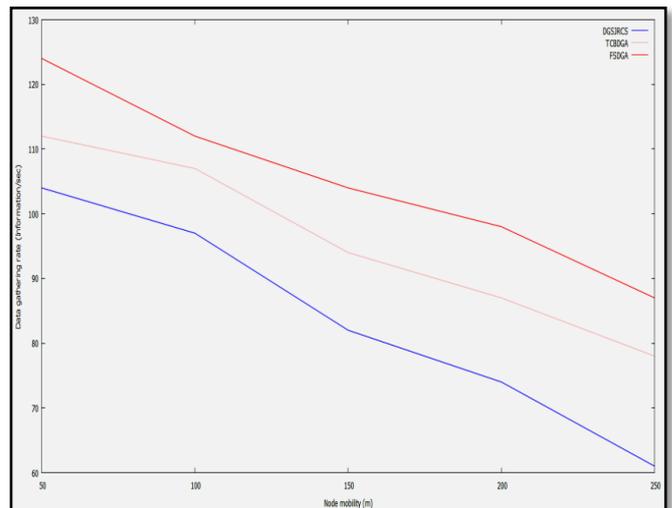
**Fig. 2. Energy conservation rate Vs Simulation time**

Fig. 2 Shows the results of energy conservation rate while varying the simulation time 0 to 100 secs. It is seen that proposed approach FSDGA provides less energy conservation rate than existing schemes. It is because of integration of fuzzy data gathering with scheduling scheme to increase energy efficiency of entire network



**Fig. 3. Data Confidential Rate Vs Number of packets**

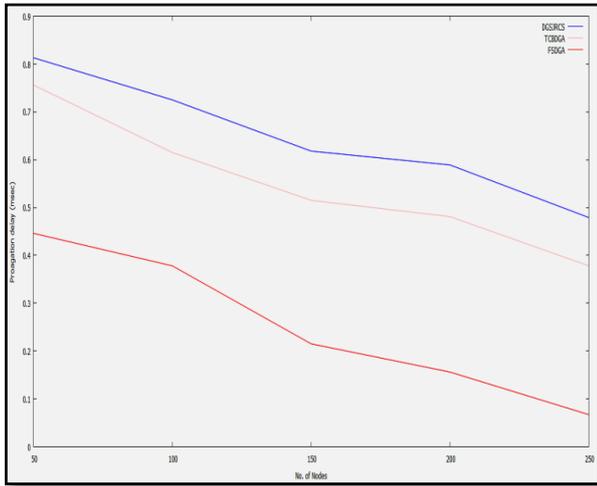
Fig. 3 Presents the data confidential rate comparison of FSDGA, DGSJRCS and TCBDGA. It is clearly seen that confidentiality status of proposed scheme is greater than existing schemes due to the integration of fuzzy and secure transmission phase. Due to network failure, confidentiality rate of proposed scheme builds the stability among the network than existing schemes.



**Fig. 4. Data gathering ratio Vs Node mobility**

Fig. 4 Illustrates the performance of FSDGA in terms of data gathering ratio due to the presence of fuzzy inference system with strong foundation of secure routes selection. Compared to existing schemes, it is seen that FSDGA achieves high data gathering ratio than previous schemes.

Fig. 5 Shows the results of propagation delay Vs Number of nodes. Cluster formation and cluster head selection are the two major pillars to reduce the propagation delay by combining network fuzzy and data transmission phase. Both modules are equally balanced to minimize the entire delay from source to destination.

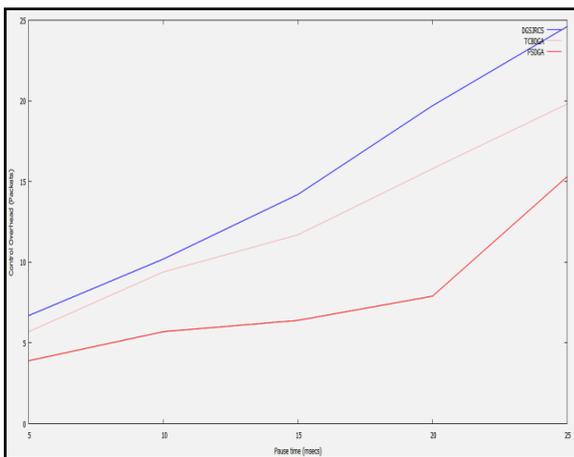


**Fig. 5. Propagation delay Vs No. of Nodes**

**Table 2. Experimental output received by proposed method**

Parameters	Results
Energy conservation	High
Simulation time	Less
Data confidential rate	High
Number of packets	Less
Data gathering	High
Node mobility	Low
Propagation delay	Low
Control overhead	Low
Pause time	Less

Fig. 6 Gives the performance of control overhead while varying the pause time from 5 to 30 msec. It is clearly seen that FSDGA provides less control overhead than existing schemes. By implementing route discovery procedure based on demand, the network vulnerabilities can be greatly reduced.



**Fig. 6. Control Overhead Vs Pause time**

## VI. CONCLUSION

In WSNs, data gathering is a big challenge to improve the network lifetime. It is very tough to balance the security and energy while focusing on data collection. If the links are

fluctuated, it may produce high overhead and less data availability ratio. To perform data collection effectively, scheduling method has to be required. In this research work, energy conservation rate and data confidentiality is balanced to attain maximum energy to improve network lifetime. The demonstration of energy conservation is done through simulation results. From the analytical results, FSDGA provides high data gathering ratio, more data confidentiality and least energy conservation rate while varying the simulation parameters such as simulation time, pause time and mobility.

## REFERENCES

1. Fei Yu, Chin-Chen Chang, Jian Shu, Iftikhar Ahmad, Jun Zhang, and Jose Maria de Fuentes, "Recent Advances in Security and Privacy for Wireless Sensor Networks", *Journal of Sensors*, Volume 2017, pp.1-4.
2. Waleed Al Shehri, "A Survey on Security in Wireless Sensor Networks", *International Journal of Network Security & Its Applications (IJNSA)* Vol.9, No.1, January 2017, pp.25-32.
3. Guangjie Han, Shanshan Li, Chunsheng Zhu, Jinfang Jiang and Wenbo Zhang, "Probabilistic Neighbourhood-Based Data Collection Algorithms for 3D Underwater Acoustic Sensor Networks",
4. Wei Liang, Yin Huang, Jianbo Xu and Songyou Xie, "A distributed data secure transmission Scheme in wireless sensor network", *International Journal of Distributed Sensor networks*, 2017, Vol.13, No.4, pp.1-11.
5. T. V. Krishna Chowdary and K. V. V. Satyanarayana, "Data Gathering in Wireless Sensor and Actor Networks", *Indian Journal of Science and Technology*, Vol. 9, No.31, pp.1-6.
6. Mariam Alnuaimi, Khaled Shuaib, Klaitthem Alnuaimi and Mohammed Abdel-Hafez, "Ferry-Based Data Gathering in Wireless Sensor Networks with Path Selection", *International Conference on Ambient Systems, Networks and Technologies*, Elsevier, Vol.52, 2015, pp.286-293.
7. Juan Lu, Adrien Van Den Bossche and Eric Campo, "An Adaptive and Distributed Collision-Free MAC Protocol for Wireless Personal Area Networks", *International Symposium on Intelligent Systems Techniques for Adhoc and Wireless Sensor Networks*, Elsevier, Vol.5, 2011, pp.798-803.
8. Sylvie Delaet, Partha Sarathi Mandal, Mariusz A. Rokicki, Sébastien Tixeuil, "Deterministic secure positioning in wireless sensor networks", *Theoretical Computer Science*, Vol.412,2011, pp.4471-4481.
9. Arezoo Abasi and Hedieh Sajedi, "Fuzzy-Clustering Based Data Gathering In Wireless Sensor Network", *International Journal on Soft Computing (IJSC)* Vol.7, No. 1, February 2016, pp.1-15.
10. Donghao Wang, Jiangwen Wan, Zhipeng Nie, Qiang Zhang and Zhijie Fei, "Efficient Data Gathering Methods in Wireless Sensor", *Sensors*, 2016, pp.1-18.
11. Khaled Almiani, Anastasios Viglas and Reza Abrishambaf, "Flow-based scheme for time-constrained data gathering in wireless sensor networks", *International Journal of Wireless and Mobile Computing*, Vol. 10, No. 1, 2016, pp.1-12.
12. K.Jaishri, P.Nandhini, S.Vijayamalathy, Mr.N.Ebenesar Jebadurai and Mr.S.Janaki Raman, "Increasing Network Lifetime and Energy Consumption for Data-Gathering in Wireless Sensor Network", *Asian Journal of Applied Science and Technology*, Volume 2, Issue 1, Pages 242-248, 2018.
13. Chunsheng Zhu, Zhengguo sheng, Victor C. M. Leung, Lei shu, and Laurence T Yang, "Toward Offering More Useful Data Reliably to Mobile Cloud From Wireless Sensor Network", *IEEE Transactions on Emerging Topics in Computing*, Volume 3, No. 1, March 2015, pp.84-94.
14. Peng Sun, Liantao Wu, Zhibo Wang, Ming Xiao, and Zhi Wang," Sparsest Random Sampling for Cluster-Based Compressive Data Gathering in Wireless Sensor Networks", *Special Section on Advanced Big Data Analysis for Vehicular Social Networks*, *IEEE Access*, Vol.6, 2018, pp.36383-36394.
15. Jan Faigl and Geoffrey A. Hollinger, "Autonomous Data Collection Using a Self-Organizing Map", *IEEE Transactions on Neural Networks and Learning Systems*, 2018, pp.1-13
16. Om Jee Pandey, Akshay Mahajan, and Rajesh M. Hegde, "Joint Localization and Data Gathering over Small World WSN with Optimal Data MULE Allocation", *IEEE Transactions on Vehicular Networking*, pp.1-15.

17. Xian ping Gu, Xiaofeng Zhou and Yanjing Sun, "A Data-Gathering Scheme with Joint Routing and Compressive Sensing Based on Modified Diffusion Wavelets in Wireless Sensor Networks", Sensors, 2018, pp.1-25.
18. Chuan zhu, Shuai wu, Guangjie han, Lei shu and Hongyi wu, "A Tree-Cluster-Based Data-Gathering Algorithm for Industrial WSNs With a Mobile Sink", Special Section on Industrial Sensor Networks with Advanced Data Management: Design and Security, IEEE Access. Vol.3, 2015, pp.381-396.

## AUTHORS PROFILE



**Dr. K. Deeba** has completed her B.E in Electronics and Communication Engineering from V.L.B Janakiammal College of Engineering and Technology, Coimbatore, Tamil Nadu, India in 1997 and M.Tech in Computer Science and Engineering from National Institute of Technology, Trichy, Tamil Nadu, India in the year 2007 and Ph.D in Anna University Chennai, Tamil Nadu, and India in the year 2013. She is currently working as a Professor at KIT-Kalaigarkaranidhi Institute of Technology, Coimbatore. Her area of research includes Networking, Multiprocessor Architecture, Parallel and Distributed Computing, Mobile Computing and Evolutionary Optimization Techniques. She has published many papers in International journals and International Conferences. She is a life member of Indian Society for Technical Education ISTE and IAENG. She is an active consultant for Research Projects. She has received Women Researcher Award and Dr. A. P.J Abdul Kalam's Researcher Award for her Academic and Research Performance. She has 18 years of teaching experience.



**S. Tamizharasi** has completed her B.E in Electronics and Communication Engineering from Sri Lakshmi Ammal Engineering College, Chennai, Tamil Nadu, India in 2006 and M.E. in Applied Electronics from Selvam College of Technology, Namakkal, Tamil Nadu, India in the year 2014. She is currently doing Research(PhD) under Anna University Chennai, Tamil Nadu, India. She is currently working as a Assistant Professor at RVS College of Engineering and Technology, Coimbatore, Tamil Nadu, India. Her Research area includes Networking, Image Processing, Wireless Communication, Modeling and Simulation and Soft Computing Techniques.



**T. Vinoth Kumar** has completed his B.E in Electrical and Electronics Engineering from Maharaja Engineering College, Coimbatore, Tamil Nadu, India in 2007 and M.E. in Control and Instrumentation Engineering from Anna University, Regional centre, Coimbatore, Tamil Nadu, India in the year 2010. He is currently doing Research(PhD) under Anna University Chennai, Tamil Nadu, India. He is currently working as a Assistant Professor at RVS College of Engineering and Technology, Coimbatore, Tamil Nadu, India. He is a life member of Indian Society for Technical Education ISTE and IAENG His Research area includes Control systems, Renewable Energy Systems, Modeling and Simulation, Networking and Soft Computing Techniques